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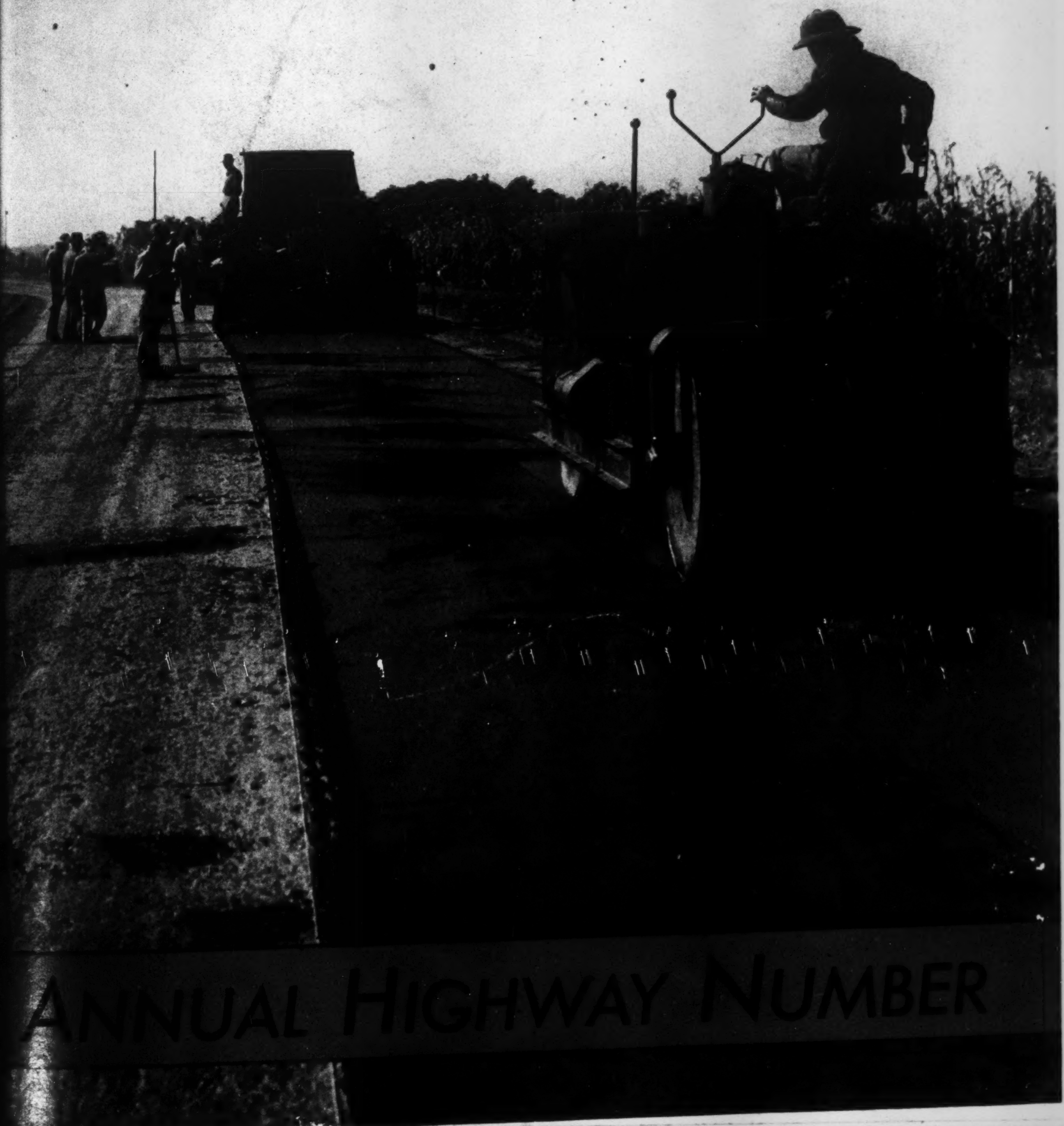

ANNUAL HIGHWAY NUMBER

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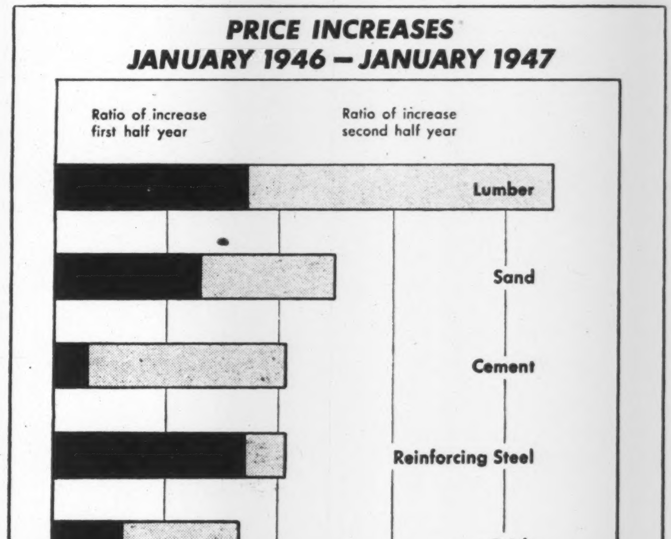
Construction Trends

Material and Wage Price Increases in 1946 Range from 11.2 to 43.6 Percent

Construction material and wage prices recorded gains in 1946 ranging from 11.2 percent for skilled labor wages to 43.6 percent for lumber, according to the *Engineering News-Record* 20-cities average. The portion of these gains realized in the first half of 1946 ranged from 2.9 percent for cement to 16.9 percent for lumber. The remaining increases, effected in the latter half of 1946, ranged from no change in the base price of structural steel to 26.7 percent for lumber.

Lumber has led the parade of price increases with its year's gain of 43.6 percent. The composite average price rose $9.28 per M ft.b.m. during the first half of 1946, and an additional $14.62 in the second half. Sand, with an increase for the year of 24.8 percent, rose $0.16 per ton in the first six months, and $0.15 in the last six months. Cement prices rose 20.4 percent in 1946, a gain of only $0.08 per bbl. in the first half, compared to a jump of $0.48 in the second half. The warehouse price of reinforcing steel, which includes freight charges, also increased 20.4 percent, but the major portion of the rise, $0.47 per cwt., occurred in the first six months. A gain of only $0.10 per cwt. was realized in the last six months. Brick rose 16.3 percent in 1946, a gain of $1.22 per M in the first half, and $2.02 in the second half. Structural clay tile, with a 12-month rise of 14.5 percent, increased $5.41 in the first half and $7.56 in the second half. The base mill price of structural steel rose 11.9 percent in 1946; the total gain of $0.25 per cwt. occurred in the first half. Ready-mixed concrete increased 11.5 percent, a gain of $0.43 per cu. yd. in the first half, compared to a gain of $0.45 in the second half.



ENR Business News

Wage rates, contrary to most material prices, rose more in the first six months of 1946. Common labor wages were increased 16.8 percent in 1946 by a rise of $0.11 per hour in the first half and $0.05 per hour in the second half, according to the *ENR* 20-cities common labor average. Skilled labor wages rose 11.2 percent, $0.11 an hour during the first six months and $0.08 in the last six months, according to the *ENR* 20-cities skilled labor average.

Since removal of construction price controls on November 9, 1946, lumber prices increased 17.9 percent; cement, 6.1 percent; brick 4.1 percent; structural clay tile, 3.9 percent; sand, 2.8 percent; and ready-mixed concrete, 2.4 percent. This represented a two-months increase of $11.96 per M ft.b.m. for lumber, $0.19 per bbl. for cement, $0.92 per M for brick, $3.81 per M for structural clay tile, $0.20 per cu.yd. for ready-mixed concrete, and $0.04 per ton for sand.

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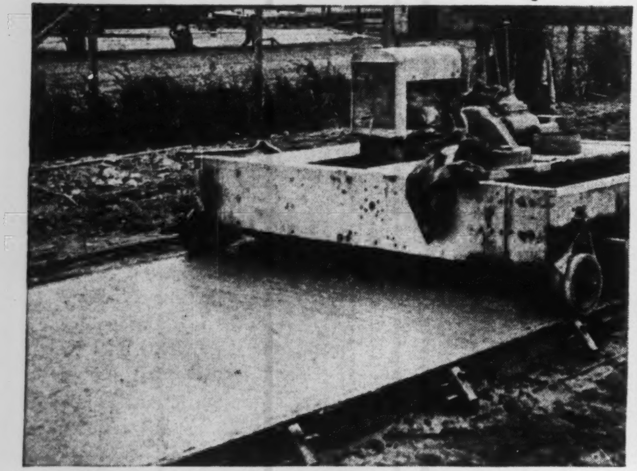

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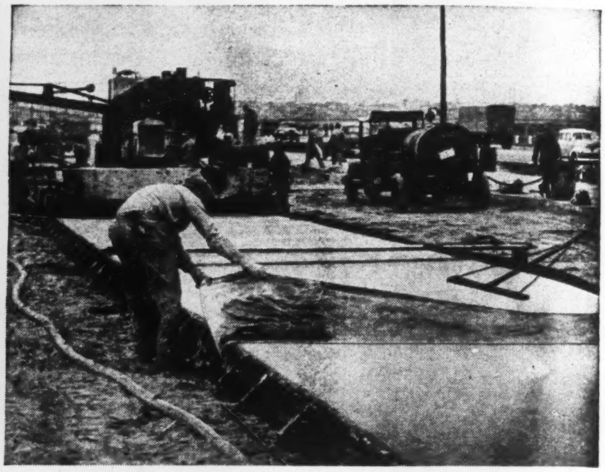

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ENR-D 48

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News of the Week

ENGINEERING NEWS-RECORD • JANUARY 23, 1947 • VOLUME 138 • NUMBER 4

ASCE president asks action on dues and junior members

Technical sessions of annual meeting highlighted by symposium on multiple-purpose reservoirs and flexible bulkhead design symposium.

Departing from a tradition that restricts the incoming president to a few polite generalities, Edgar M. Hastings, new president of the American Society of Civil Engineers, opened his term of office with a strong appeal to the members to act as quickly as the constitution will permit on the two matters that he considers of utmost importance to the society, namely, granting corporate membership to the juniors who now have no voice in society affairs, and an increase in membership dues to permit the society to function effectively.

Both subjects had been under active discussion at the 2-day meeting of the Board of Direction, which preceded the society's 94th annual meeting held in New York Jan. 15-17. At the board meeting it was decided to ask local sections in each zone to circulate petitions asking for constitutional amendments covering these two specific matters. Previously, it had been planned to postpone action on the question of corporate status for juniors until the much broader question of an overhauling of the society's entire system of grading members was ready for presentation to the membership.

Expanded activities

Mr. Hastings' statement came at the close of the opening session at which the society's awards and honorary memberships had been conferred (*ENR* Jan. 16, vol. p. 81). In accepting the presidency, he said that the society had taken on new responsibilities in order to play a better part in national and international affairs, and that as a result the society is now operating in the red. To meet this latter condition, the outgoing board, Mr. Hastings said, had recommended an increase of $5 in corporate member dues and $2.50 in dues for juniors, which proposal he heartily approved and will foster.

As to the juniors, Mr. Hastings said that the society needs new blood to meet its new problems, which he believes can best be obtained by giving juniors a greater voice in society affairs. "I am convinced," he added, "that a man who is old enough to vote for city, state and federal officers is old enough to vote in this society." As the matter of giving these young men a vote is only remotely related to the more controversial issue of changes in the upper grades, Mr. Hastings said that he favors the separate action recommended by the board and expects to work for it aggressively this year.

The sessions attracted the largest registration of society members ever to attend an annual meeting. Society officials reported that the total registration would "closely approach" 2,500. During the 3-day meeting, the groups listened to and discussed the many papers on multi-purpose reservoirs, flexible quaywall design, city planning, sanitary engineering, surveying and mapping, highways, and many other specialized matters that are reported in some detail in the succeeding news pages.

Multi-purpose storage reservoirs

After making clear at the outset that their ideas with respect to design, and operation of multi-purpose reservoirs would be in conflict, Col. Malcolm Elliott, U.S.A. (Retired) and Nicholls W. Bowden, chief of the river control section of the Tennessee Valley Authority, found themselves in virtual agreement, to their expressed surprise. In such an atmosphere a 2-day Hydraulic Division symposium on the subject got under way, to produce the harmonizing of views that Raymond A. Hill, consulting engineer of Los Angeles, said was the objective.

Although pointing out the conflicting requirements of operation of reservoirs for both flood control and navigation, Colonel Elliott pointed out that such multi-purpose use is possible if (1) the reservoir is far enough upstream so that most of the valley is below it, yet not too far above the head of navigation and (2) that sufficient storage for both purposes is provided. Fort Peck reservoir, he said, does not meet these specifications closely since it is too far above the head of navigation.

Joint use of some reservoir storage is only possible when floods can be absolutely predicted, and there are few basins in which this can be done. He mentioned only the Tennessee basin as a possibility, although John C. Stevens (Portland, Ore.), in discussion, added the Willamette valley in Oregon and the Sacramento valley in California. Colonel Elliott said dual purpose must be designed into reservoirs, and the flood storage portion zealously retained for that purpose only.

The U. S. Reclamation Bureau, starting out in 1902 with irrigation as the only purpose for storage, has continuously widened its perspective and philosophy until such multiple purposes as power, flood control, navigation, silt control, recreation, and fish and wild life protection are now covered. This has been possible through acts passed by Congress permitting costs of such uses to be carried by the federal government rather than being absorbed by the users of irrigation water, according to E. B. Debler, regional director, Denver.

Flood crisis reduced by TVA

Mr. Bowden outlined the successful operation of the Tennessee Valley dams in lowering flood crests at Chattanooga, Paducah and Cairo. Experience in operation is being accumulated so that even greater future efficiency is assured. TVA fills its tributary reservoirs during the first four or five months of the year, maintains high levels for two or three months, and then draws them down. It also varies water elevation up and down a few feet in summer and

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early fall to kill malaria larvae. Never yet has all the available flood storage in any of the tributary reservoirs been fully used.

Chattanooga flood crests are lowered by holding flood waters in tributary reservoirs, while Cairo and Paducah get their protection from Kentucky Reservoir near the mouth of the Tennessee. One way of operating the latter is to discharge ahead of crests in the Ohio and Mississippi, then to withhold the Tennessee floodwaters until those crests have passed. Fourteen floods in 12 years at Chattanooga have been reduced from 1 to 10 ft., affecting a saving from damage estimated at $12,000,000. Cairo crests have been lowered from 0.7 to 1.7 ft., enough to permit the Mississippi River leveed channel to carry the largest floods on record.

Flood control and navigation

Policies of federal departments with respect to multiple-purpose reservoirs were discussed in more detail at the second session of the Hydraulics Division, starting off with the flood-control and navigation work of the Corps of Engineers. Albert L. Cochran, hydraulic engineer, office of the Chief of Engineers, on the matter of the use of flood storage areas for other purposes, which was raised at the earlier session, said that reservoirs fall into two classes, those in which this should not be permitted due to uncertain timing of floods, and those in which it can be done safely during seasons of the year when it is known that floods will not occur. Such use of part of the flood storage zone in the latter class of reservoirs has a high economic value when flow for power or navigation can be reregulated by that procedure, Mr. Cochran said.

How multiple-purpose reservoirs can be used to aid navigation was told in a paper by R. J. Pafford, Jr. of the Missouri River Division office, who centered his discussion on the proposed development of the Missouri for navigation, power, irrigation and flood control. Mr. Pafford stressed the need for large storage space in the reservoirs well down on the main stem of the river if all four purposes are to be adequately served. By this means, water released from the upper reservoirs for power and irrigation can be recaptured in the lower reservoirs and used for navigation and more power.

Wesley R. Nelson, regional director of the U. S. Bureau of Reclamation at Amarillo, Texas, amplified what had been said earlier in Mr. Debler's paper about the progressive development of the bureau's reservoirs for purposes other than irrigation.

Mr. Nelson observed that there is much dissimilarity in the approach of the several federal departments to water questions and suggested that the ASCE do what it can toward fostering the development of a national water policy.

Other federal agencies

Following Mr. Nelson's paper, the influence of other federal agencies on multiple-purpose reservoirs was discussed by representatives of the Federal Power Commission, the Fish and Wild Life Service, Park Service and Weather Bureau. E. Robert DeLuccia of the power commission staff told how that staff had cooperated with the Corps of Engineers in the development of designs for power facilities at flood-control dams to produce designs that would permit the generation of much more power than had been anticipated in the original studies.

The Fish and Wild Life Service is chiefly interested in the manner in which reservoirs are operated, according to R. Dieffenback, but the design of outlet works also is of concern to that agency due to stratification of water in reservoirs. Outlets at various levels are favored.

Merrill Bernard of the Weather Bureau urged the Hydraulics Division to use its influence to get the great mass of rainfall data now in the bureau's files transferred to punch cards for analysis. This information would be of unestimable value to engineers in predicting floods and flood runoffs he said.

Although not a part of the multipurpose reservoir symposium, A. V. Karpov, in a paper before the Power Division, described the dual purpose (power and irrigation) reservoirs of North Africa which are designed, in contrast to the usual practice, to hold more than a single year's runoff—some as much as three years. Except in unusual circumstances all water is discharged through the turbines, and all is fully used for irrigation.

Tests probe design of bulkheads

Because flexible bulkheads—steel sheetpiling confining backfill, and either anchored or attached to relieving platforms so as to form a quay wall—have been designed more by guess than by carefully gathered data, the Navy Bureau of Yards and Docks has sought to remedy the situation by a series of large-scale earth pressure tests assigned to Prof. Gregory P. Tschebotarioff and a research staff at Princeton University.

The results of these tests to date, as well as their possible application to design and other aspects of the problem, were presented in a series of papers before the Soil Mechanics and Foundations Division in what turned out to be the best attended sessions of the convention.

The testing installation, located under Palmer Stadium at Princeton, is believed to be the most extensive of its kind ever built, and permits testing a bulkhead about 11 ft. high and 5 ft. wide. Tests were made primarily to determine the amount of sand necessary to interpose between the sheetpiling and a hydraulic high-clay-content backfill to decrease effectively the fluid lateral pressure of the unconsolidated backfill against the sheetpiling. Measuring instruments used included extensometers, SR-4 electric resistivity strain gages, dynamometers for reaction pressures and Carlson pore pressure cells.

Professor Tschebotarioff reported that a sand dike, sloping away from the bulkhead on a 1:1.7 natural slope, (and with a 1 ft. wide berm at the top) was fully effective in reducing fluid lateral pressures to values no greater than exerted by a backfill composed entirely of sand. Equally effective was a vertical sand blanket of a width equal to the bulkhead height, but reducing the width quickly reduced the effectiveness. The sand dike of course does not speed up the consolidation and thereby the supporting power of the clay backfill, and for this resort must be had to a pumping system connected to a pattern of horizontal sand drains (burlap cylinders filled with sand); to vertical sand drains or similar devices.

It was also determined by corollary tests that consolidation of fluid clay backfills reduces pore pressures in the backfill and bending deflection and lateral pressures on the sheet piling: conventional stress-strain concepts do not apply, however. Nor does induced outward tilting of the top of the bulkhead decrease further the "consolidated equilibrum" pressures in the upper zone of the backfill, as sometimes is assumed, although pressures in the lower zone are decreased. Another significant finding was that consolidated clay and consolidated clay-sand mixtures exert very similar lateral pressures, although laboratory tests show them to have completely different characteristics. Finally, there was no evidence in the tests that vertical arching of the sand behind a bulkhead offers any pressure relief, as is sometimes assumed.

That the results to date of the tests have immediate applicability to design was pointed out by Harris Epstein, head designing engineer of the Bureau of Yards and Docks. The sloping sand

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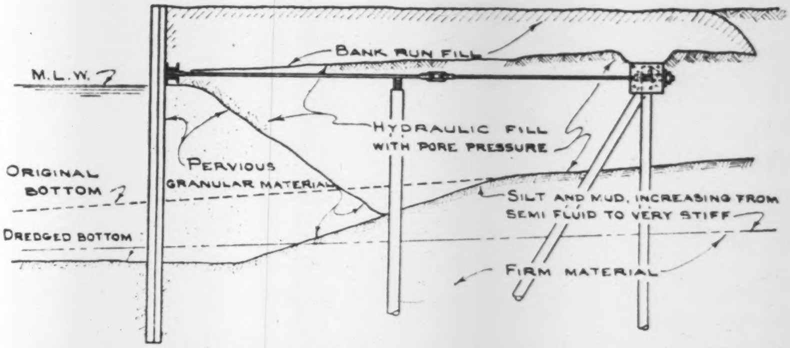
blanket, should be used in practice because of its ease of placement. Also if the top berm is kept to less than 0.135 times the height of the wall, the sloping dike will require less material. However, Mr. Epstein surmised that the berm width might have to be as much as 0.4 the height to make the sand dike fully effective under surcharge loads.

Mr. Epstein pointed out that bulkheads seldom if ever develop trouble from failure of the piling because it is designed with a much higher factor of safety than is available in soils from friction and cohesion. Moreover, the tests show no beneficial effect from arching. Therefore, Mr. Epstein suggests that rational design would reduce the factor of safety in design of the structural parts of a quay wall by increasing allowable design unit stresses.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DREDGED BOTTOM
FIRM MATERIAL

***Proposed method** of Bureau of Yards and Docks for constructing anchored quay walls using a pervious sloping sand dike between the sheetpiling and the hydraulic clay fill, as investigated in Navy-sponsored tests at Princeton.*

Bulkhead failures analyzed

That additional design knowledge on quay walls will be useful was emphasized in papers presented by Capt. J. C. Gebhart (CEC) and Comdr. Lewis C. Coxe (CEC) design manager and assistant, respectively, of the Bureau of Yards and Docks, U. S. Navy.

Sand leaks through a concrete sheetpile cutoff along the face of a relieving-platform type quay wall and undermining that permitted failure were then described by Captain Gebhart. The sheetpiles were not interlocking but an attempt was made to grout the tongue and groove joints between piles. After completion, the ocean-side of the quay wall was dredged out. The sand apparently formed a vertical "pipe" of moving quicksand, flowing through water and out through openings that were not completely stopped by grouting—causing ultimate failure of sections of the wall. Openings extended as much as 60 ft. inland with depths of 35 ft. while one cave-in involved loss of about 8,000 cu.yd. of material. The correction was to provide more positive grouting and to do the dredging along the water side in vertical stages so that a smaller area was exposed at a time.

The use of vertical sand drains in plastic clays to stabilize support for a similar quay wall was described by Commander Coxe. General dredge excavation to 30 ft. below mean low water was followed by refilling with 20 ft. of sandy material and then driving wood supporting piles and 2 ft. thick concrete sheetpiles to a depth of about 80 ft. Cracks appeared in the face of the quay wall soon after it was backfilled.

Apparently the excessive lateral pressure acting on the bulkhead and causing failure was due to pore pressure both in the backfill and in the fine grain clay underlying the backfill. The pore pressure was relieved by installing vertical sand drains to a depth of 80 ft., about the bottom depth of the piles. Drains were spaced in an 8x10-ft. pattern under the relieving platform while drains back of it were spaced 12x13 ft.

The sand drains were placed by driving a 12-in. dia. steel pipe with a collapsible cap at the lower end. Difficulty in forcing the sand out as the steel pipe was withdrawn was overcome by placing an airtight cap on the top of the mandrel after it was filled with sand and applying air pressure as the casing was withdrawn. A surcharged load in the form of a sand blanket was placed over the fill temporarily to assist in forcing water out of the material.

Carrying the practical application of the principles of soil mechanics farther two other Navy jobs were described by L. A. Palmer, soil mechanics engineer of the Bureau of Yards and Docks. On one a 90 ft. homogeneous clay deposit of sedimentary origin was found to have a density and moisture content apparently unrelated in depth. On the second job a cellular sheet-pile cofferdam-type pier filled with and supported on sand was found to be safe even under severe earthquake shock. Use of sand filling resulted in a considerable reduction of cost below that estimated for filling by broken rock or other available material that might have had greater stability.

The single session of the Waterways Division was devoted to a discussion of port terminal requirements with the one formal paper presented by C. R. Denison, port development engineer of the U. S. Maritime Commission. Mr. Denison advocated marginal wharves rather than piers for better access and the use of more port equipment, especially level-luffing cranes.

That improvement can be made in operation of our home ports is shown by the fact that they are only 56 percent as efficient as terminals in other ports operated by U. S. forces. Also, the best foreign ports are far ahead of ours in handling packaged cargo, though our terminals for passengers and bulk freight (such as ores) are reasonably efficient and well managed.

That obsolescence is more important than probable useful life when studying port structures was pointed out by Charles T. Leeds of Los Angeles in discussing Mr. Denison's statement that the structure above the deck can well be designed for shorter life than the substructure.

Written discussion by John Ayer of Boston stated that piers should be at least 200 ft. wide compared to Mr. Denison's suggested 160-ft. wide for wharves parallel to the shore. Stacking height in pier sheds has been greatly increased recently by the use of hydraulic lifts. Floor loads of 500 psf. for 12-ft. stacking height and 800 psf. for 17-ft. stacking height appears to be adequate.

Sanitary division discusses pollution

Treatment of industrial waste for the recovery of by-products alone does not in itself offer much prospect as a profitable venture, in the opinion of F. W. Mohlman, director of laboratories of the Sanitary District of Chicago, who addressed the Sanitary Division on possibilities of recovery utilization.

He pointed out that the course of industrial practice is characterized by the progressive recovery, and salvage, of products once discharged into sewers as worthless waste. The line of distinction between salvage and waste is steadily moving toward recovery of products within the factory, thus relieving the pollution load contributed by these wastes.

What this pollution load can amount

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to was evidenced from data obtained in scores of plants. Analysis of the sewered wastes from various industries showed that the pollution values—in terms of population equivalent per ton of raw material processed—were as follows: Packinghouses, 173; brewery, 142; corn-products refining, 29; by-product coke plants, 11; and laundries, 600. Particular attention was invited to the latter figure, which revealed that contrary to popular belief, laundry wastes have a far greater pollution effect than many other types of industrial discharges.

Waste recovery profitable

Manufacturers have come to regard salvage treatment measures as part of regular factory operations, said Dr. Mohlman, and one-time losses such as gluten, feed, grease, yeast and other products are no longer classed as wastes but as primary products whose recovery is a profitable processing measure.

Another aspect of industry's role in the abatement of stream pollution was described by Ogden F. Jones, chief geologist of the Kansas State Board of Health, who praised the oil industry for its cooperative efforts. He described methods of pumping brine back into the ground at depths sufficient to eliminate contamination of surface water.

These brines, which result from the tapping of oil at great depths where it is associated with salt water have six times the concentration of chlorides and contain seven times the solids of seawater, said Mr. Jones. Some of them contain 248 times the concentration of solids and 400 times the concentration of chlorides that are considered as maximums under the U. S. Public Health Service standards of drinking water quality. As a basis for appreciating the pollution effect of these brines it was stated that 400 bbl. of chloride-free water would be required to dilute one barrel of brine.

Sanitation and housing

A convincing outline of the role that sanitary engineers can play in the promotion of better housing was presented by M. Allen Pond, assistant professor of public health at Yale University.

Said Mr. Pond: "There are three paths in the housing field down which sanitary engineers may be expected to go: (1) research; (2) design and construction; and (3) administration. Top priority would probably be assigned to studies of domestic sewage disposal methods. Also on the list would be original investigations into new techniques for household refuse disposal. Inspired research on plumbing may be expected, but routine application of any findings that tend to simplify present installations cannot be expected.

It was Mr. Pond's belief that sanitary engineers in private practice are likely to find increasing opportunities for employment on the design and construction of group housing. As consultants to architects, planners and builders, this group may be immeasurably useful in improving the quality and liveability of new housing through the application of tested scientific methods.

Sanitary engineers in public service—particularly those in health departments—will be called upon increasingly to participate in the replanning of communities and in the solution of existing housing problems. During the past decade, reported Mr. Pond, great strides have been taken by some city health officials toward a solution of the problem of blight and slums. Almost without exception this work has occurred in cities where sanitary engineers are employed in the health department.

The objectives of the newly formed Inter-American Association of Sanitary Engineering—an organization of sanitary engineers serving the 21 American republics—were outlined by Edward J. Cleary, executive editor of *Engineering News-Record*. Designed to provide a means for facilitating the interchange of ideas and scientific information, it will also seek to establish standards of sanitation for the Americas as well as promote good will and better understanding among sanitary engineers and other persons engaged in public health activities.

Applications for membership in the association, which has nominal dues of $3 yearly, are now being received by Donald L. Snow, acting secretary, Pan American Sanitary Union Building, Washington, D. C.

Highway traffic and bridge design

Public education to point up the evils and waste caused by inefficient circulation of people and goods was called one of the most important factors towards the solution of today's traffic congestion problem by William J. Shea, chief of staff, New York City Planning Department.

Speaking before the city planning division of the ASCE, Mr. Shea said that replies to a questionnaire sent to 27 cities with populations over 100,000 indicated that very little had been done in 1946 to improve traffic conditions permanently. However, among the traffic "palliatives" applied were: prohibition of curb parking with continuous police enforcement; one-way street improvement; reduction of left-hand turning, rerouting of transient vehicles and splitting the loading zones in downtown areas. Off-peak curb loading and unloading for trucks, and installation and re-timing of traffic signals were used effectively in some cases.

"Vitally needed in every city," Mr. Shea continued, "is the adoption of a comprehensive and integrated program of street and expressway improvements. Additional off-street parking, truck and bus terminals, improved transportation, modernized traffic engineering measures, continuous police enforcement, and public education in traffic management are essential elements in such a program."

In response to questions, Hoy Stevens, chief of the section of equipment and maintenance, American Trucking Association, said that construction of union truck terminals could contribute only partly to the solution of the problem as only two-fifths of the total tonnage entering and leaving cities passes through such a depot. Off-street parking was emphasized as the most effective, practical solution to congestion.

Tackling the formidable subject "Evolution and Coordination of Transportation" with the same zeal he displayed on the Alcan Highway and Ledo Road, Col. John W. Wheeler, now back on his old job with the C. B. & Q. R.R. gave the highway division a quick resume of the transportation systems in this country, deplored the discrepancies in taxes, summed up the history of regulation and pleaded for a sound coordination of railroad, highway, waterway and pipeline transport. All four forms of transportation must be kept in economic health, he declared, for the nation has no more commodities available for consumption than we can haul, and all four are necessary to move the nation's goods. He warned that nationalization of the railroads, freely advocated in many quarters, means nationalization of all transport, for "the government will not stand for competition."

Concrete bridge decks

Three lengthy papers describing the bridge research work at the University of Illinois were presented at the structural session. The general procedure used in the extensive testing work with large size models of both flat-slabs and reinforced-concrete decks or steel-girders was outlined by F. E. Richart, research professor of engineering materials at Illinois. The work described was done in two stages—tests with loads that created no cracking of the structures

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and with loads of larger size that produced considerable cracking. With both type of tests, the results compared favorably with the theoretical. Special loading and calibrating devices were required for the work.

Numerous tests of I-beam bridges revealed that in a reinforced concrete slab the stress in the reinforcing steel immediately beneath a single concentrated load on the deck is always considerably less than that computed by most design theories, M. M. Newmark, research professor in the University of Illinois civil engineering department, reported. This finding was not considered unreasonable by Professor Newmark, since he views the theory applying to the immediate region of the load as not properly applicable to the reinforced concrete after cracking.

Ten years of work by Professor Newmark has convinced him that generally too much longitudinal reinforcing is used in slab and steel-girder bridges. Considerable work with composite I-beam bridges revealed that stress theories for this type of structure were also considerably on the conservative side, Mr. Newmark further reported. He believes that the amount of horizontal steel provided by using most theories of design could be reduced by about 30 percent.

The extensive work on evaluating the action of shear construction in composite I-beam construction at Illinois was described by C. P. Siess of the university's testing laboratory. His paper dealt in considerable detail with the effectiveness of connectors made of short lengths of light channels welded to the upper flange of the beams in a transverse position.

The effectiveness of such connectors, Professor Siess reported, was approximately proportional to the length of the connector. Variations in web thickness of the channels produced variations in the effectiveness of the connectors, although the magnitude of the changes was far less than would be expected from the changes in the section modulus of the web. It was found that increasing the compressive strength of the concrete increases the effectiveness of the connectors. The channels act like dowels, it was concluded.

Bridge clearances

A symposium on the problem of bridge clearances arranged by the oint Committee on Waterway Clearances, Charles T. Leeds, consulting engineer, Los Angeles, chairman, failed to bring out many problems. Rather, there seems to be wide satisfaction with the current practices of the War Department in this often controversial activity of fixing horizontal and vertical bridge clearances. Lieut. Gen. Raymond A. Wheeler, Chief of Engineers, stated that the War Department policy involves first the establishment of standard bridge clearance guides for all important waterways, and second, the examination and study of each particular bridge in the light of local and modern conditions. Mistakes have been made, General Wheeler admitted, but they have been few, and every attempt is made to weigh all conflicting interests. The most important point brought out in discussion is that for fixed bridges vertical clearance has the most direct effect on costs, and that every attempt should be made to keep it to a minimum.

Construction education

The need for construction education training in engineering schools was pointed out by Harold Richardson, Executive Editor, *Construction Methods*. Mr. Richardson called attention to the fact that construction is civil engineering's biggest industry and the country's second industry, yet it is largely ignored by civil engineering courses. The development of construction equipment, which makes modern construction possible, was also pointed out as a subject ignored in engineering training. He suggested elective courses in labor relations, job management, equipment use and application, safety and other construction procedures be offered to students bent upon a building career.

Discussion, led by Frank A. Nikirk of Milton-Hale Machinery Co., Albany, N. Y., emphasized the importance of teaching the use of equipment. Professors in attendance were divided in opinion, some claimed theoretical courses are more important in developing the student mind, but others agreed that the colleges were falling short in training civil engineering students for careers in industry.

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Aerial mapping for highway studies

Aerial surveys in 1941 for the Palisades Parkway in New York State cost only $17,500 for work that was expected to cost $75,000 by ground survey methods, Edward T. Gawkins, deputy chief engineer of the New York Department of Public Works told the Surveying and Mapping session. Mr. Gawkin's department has been using aerial photographs on highway work since 1926 and at present has aerial topographic mapping projects underway in seven separate areas of the state. The average cost of aerial topographic maps of New York highway development has been $1 per acre for a strip one mile in width, including the price of a set of vertical aerial photographs at a scale of 1″ equals 500 ft. Although he feels engineers have only begun to utilize the full advantages of this modern tool in highway design, Mr. Gawkins stressed, however, that aerial surveys have not completely eliminated the need for basic ground surveys. This need also was stressed by Philip Kissam, chairman of the meeting.

Aerial mosaics covering an area 1,500 ft. wide cost New Jersey from $600 to $800 a mile, according to Spencer Miller, Jr., commissioner, New Jersey State Highway Department.

Mr. Miller placed special stress on the value of aerial surveys in preliminary studies and in making locations through built up areas where the arrival of ground survey parties frequently arouses hostility and undesirable speculation in real estate. His department has also found large air views of great help in presenting projects to the public.

Mr. Miller also laid special emphasis on the importance of having the highway engineers fly over the routes under study. He said that he had recommended to S. Johannesson, head of his planning division, that he have the whole division fly over the areas now under study.

Wm. J. Cox, head of the Connecticut Highway Commission described how his department is using large scale aerial maps in a study of the relocation of U. S. Route 1 through the easterly approach to New Haven.

Mr. Cox said that they had had maps made covering an area one mile wide. These cost $885 a mile. The inked maps are at a scale of one inch equals 200 ft. and have 5-ft. contours.

Mountain highway work

How the Massachusetts Department of Public Works has used aerial maps to great advantage in relocating Route 20 through the mountainous country west of the Connecticut River was told by E. C. Houdlette, director of the survey division. The cost of ground reconnaisance surveys was estimated at $1,200 a mile for 19 miles and would take 6 months. The aerial surveys cost $629 per mile (86c. per acre) and covered a strip 6,000 ft. wide.

Mr. Houdlette stated that his department has entered into a contract with Harvard University to make a very thorough study of aerial surveying for highway purposes. It will include a determination of the best types of camera lenses, films and filters, also the best elevations from which to take photos for specific purposes. The results of the survey are to be published.

NEWS IN BRIEF

In telegraphic form, here are latest news developments on the engineering and construction front during the week.

Construction—L. B. Smith Industries is planning an 8-story apartment hotel at *Harrisburg, Pa.*, to cost $1,750,000 . . . Gulf Oil Corp., *Philadelphia, Pa.*, has announced the Lummus Co., New York City, as general contractor for a new $3,500,000 polyform unit refinery. . . . Early start on a $2,500,000 market at *Montreal, Que.*, is predicted . . . A $1,200,000 power plant and track work at *Sewaren, N. J.*, for the Public Service Electric and Gas Co., has been approved . . . Construction of the second and main unit of the Johns-Manville's research center near *Bound Brook, N. J.*, has been started . . . Consolidated Steel Corp. has a contract from the El Paso Natural Gas Co. for the fabrication of about 100 miles of 26-in. pipe for 1947 delivery at a price exceeding $2,500,000. It will be laid east of the *Colorado River* . . . The University of Tennessee, *Knoxville*, has a proposed $15,000,000 building expansion program . . . The Eddy Paper Corp. will erect a factory building at *Rockford, Ill.*, which, with equipment, will cost $1,000,000 . . . General Electric Co. will build a laboratory to test jet engines at *Lynn, Mass.* . . . Rohm and Haas, plastic manufacturers, will build a $1,000,000 plant on a 500-acre site on the Ship Channel at *Houston, Tex.* . . . The Tex-Mex Cement Co. will build a $5,000,000 portland cement plant at *Corpus Christi, Tex.* . . . Building permits totalling almost $11,000,000 were issued in 1946 at *Wilmington, Del.* . . . Construction at *Richmond, Va.*, in 1946 totalled 1,677 buildings estimated to cost $13,555,129.

Highways—Approximately $9,975,000 will be spent during 1947 for reconstruction, widening and resurfacing existing roads by the *Pennsylvania* Department of Highways, reported Secretary Ray F. Smock. This will cover the improvement of 417 miles of highway . . . Governor W. W. Bacon of *Delaware* has recommended appropriations of $2,000,000 besides amounts included in the regular budget of the state highway department to match federal funds.

Water supply and sewers— *Altoona, Pa.*, has plans nearly completed for two sewage disposal plants to cost $1,300,000 . . . A water supply totalling 10,000,000 gpd. may be developed for *Jamestown, N. Y.*

Foaming of waste sulphite liquors seen as effective treatment method

New York State Sewage Works Association told of experimental work on industrial waste—Martin elected president.

Possibilities of a new method for the treatment of concentrated waste sulphite liquors, based on intensive aeration to induce foaming, was described before the New York State Sewage Works Association meeting in New York City Jan. 18.

R. P. Logan and H. Heukelikian, assistant and associate of the department of sanitation, New Jersey Agricultural Experiment Station, told of laboratory experiments in which they aerated this heavy, syrupy waste in contact with biological growths. They compared the effectiveness of so-called foam-phase and liquid-phase oxidation.

The foam-phase treatment consisted of agitating the sulphite waste violently with air to produce a complete foam. This reduced the biochemical oxygen demand 80-85 percent in 24 hr. and as much as 50 percent in 6 hr. Contrasted with this were results obtained from the more orthodox method of simply aerating the liquid without attempting to create foaming. Here the reduction in B.O.D. was not in excess of 30 percent in 24 hr.

Stream pollution analysis

Also highlighted on the program was an explanation of stream pollution and self-purification, using financial comparisons as an analogy, provided by Prof. C. J. Velz, head of the civil engineering department, Manhattan College, New York. He termed dissolved oxygen content and reaeration phenomena as assets of streams; the B.O.D. of pollution was regarded as a liability and an outstanding debt. He pointed out that if the demand for oxygen is excessive in relation to that made available, the stream goes into "bankruptcy" and nuisances result.

Wellington Donaldson, chief of the bureau of sewage disposal, New York City, was honored with the Kenneth Allen Memorial Award, given by the Federation of Sewage Works in recognition of his many accomplishments in the management of sewage disposal operations. Also recipients of a Kenneth Allen award, were Thomas Riddick, consulting engineer, and H. O. Johnson, operator, of Great Neck, for their paper on sludge removal.

The Lewis V. Carpenter Award was given to Uhl T. Mann, operator of the Syracuse, N. Y., sewage treatment works.

For the coming year Alexander G. Martin, of Tonawanda, and Edwin C. McKeeman, of Freeport, were elected president and vice president, respectively. A. F. Dappert was reelected secretary-treasurer.

Francis Friel, consulting engineer and president of the Federation of Sewage Works Associations, reported that membership had increased 32 percent in six years and that 29 sections comprise the association, four of which are in countries outside the U. S.

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Rudolph P. Miller dies, expert on buildings

Rudolph P. Miller, 80, former superintendent of buildings for the Borough of Manhattan, N. Y. City, died in White Plains, N. Y., Jan. 18. He received a civil engineering degree from Columbia in 1888, and, after some railroad experience Mr. Miller entered city service as a building inspector. From 1900 to 1905 he was chief engineer of the building department, and then served as building superintendent from 1905 to 1910, and again from 1920 to 1922. From 1922 until his retirement in 1943, he was a consulting engineer.

MAJOR MEETINGS

Associated General Contractors, annual convention, Stevens Hotel, Chicago, Ill., Jan. 27-30.

National Crushed Stone Association, annual meeting, Edgewater Beach Hotel, Chicago, Ill., Jan. 27-29.

Associated Equipment Distributors, 28th annual meeting, Edgewater Beach Hotel, Chicago, Ill., Feb. 13-15, 1947.

American Road Builders Association, annual convention, Palmer House, Chicago, Ill., Feb. 17-21.

American Concrete Pipe Association, annual national convention, Statler Hotel, St. Louis, Mo., Feb. 23-25.

American Concrete Institute, 43rd annual convention, Netherlands Plaza Hotel, Cincinnati, Ohio, Feb. 24-26.

National Council for Stream Improvement, annual meeting, Waldorf Astoria Hotel, New York, N. Y., Feb. 24-26.

American Society for Testing Materials. Committee Week, Benjamin Franklin Hotel, Philadelphia, Pa., Feb. 24-28.

Association of Highway Officials of the North Atlantic States, 23rd annual meeting, Hotel Traymore, Atlantic City, N. J., Feb. 26-28.

OBITUARY

Frederick Robert Shaffer, 66, Spruce Pine, N. C., who for the last four years has been employed at Oak Ridge, Tenn., died Jan. 11. He obtained his civil engineering degree from Pennsylvania State College and formerly was associated with the Pennsylvania Railroad and the Western Electric Co.

Alexander Greig Fleming, 65, civil engineer, died at Montreal, Ont., Jan. 8. A graduate of Queen's University, Kingston, Ont., he formerly was with the Canada Cement Co.

J. Albert Holmes, Somerville, Mass., retired civil engineer, died Jan. 1. Mr. Holmes was graduated from Norwich University in 1895. He served in the engineering departments of Cambridge, Somerville and Boston and was general superintendent of parks in Cambridge. He supervised the construction of the Charles River Drive in Cambridge.

James H. Dawes, 86, engineer, who constructed waterworks, electric plants and railroad facilities throughout the eastern seaboard states, died in Philadelphia, Pa., Jan. 14. His work included construction of the water system of the Pennsylvania RR, dredging of the N. Y. State Barge Canal, and part of N. Y. City's Catskill aqueduct.

Edward Anderberg, 65, of White Plains, N. Y., an engineer with the Bureau of the Budget for five years, died in Washington, D. C., Jan. 18. He had previously worked for the N. Y. State Barge Canal and had been division engineer for the Westchester County Park Commission. He had civil engineering degrees from New York University and had taken special technical courses at Columbia University. Recalled from retirement at the outbreak of the war, Mr. Anderberg served with the war projects unit of the bureau, and since the war he had prepared technical reports on military and civil works projects of the Corps of Engineers.

William N. McDonald, 77, retired civil engineer, died in Jacksonville, Fla., Jan. 6.

Carlisle Madson, 53, a civil engineer employed by the state of Minnesota for a number of years, died in Minneapolis, Jan. 4.

L. Vincent Metz, 74, civil engineer and surveyor, died at Erie, Pa., Jan. 5.

Rear Adm. Bruns dies, was Pacific engineer head

Rear Admiral Henry F. Bruns, 57, director of the Pacific Division of the Bureau of Yards and Docks, died in Oakland, Calif., Jan. 20. An Annapolis graduate, (1911) he received a degree in civil engineering from Rensselaer Polytechnic Institute in 1914. He served on construction in Cuba, and later was public works officer at several locations. From 1934 to 1937 he was project manager for the bureau on construction of ordnance projects. From 1938 to 1941 he served as public works officer at Pearl Harbor and for the 14th naval district, supervising construction at Pearl Harbor and other Pacific locations. In June, 1942, he became public works officer at the naval operating base at San Diego, Calif., and later supervised all naval shore construction on the west coast. During the last half of 1945 Admiral Bruns served as Director of the Atlantic Division, and early last year he was assigned to the Pacific Division post.

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Lt. Gen. D. I. Sultan dies; Army Inspector General

Lieut. Gen. Daniel I. Sultan, 61, civil engineer, Army Ground Forces commander in the China-Burma-India theater from Oct., 1944, to June, 1945, and since July, 1945, Inspector General of the Army, died in Washington, Jan. 14.

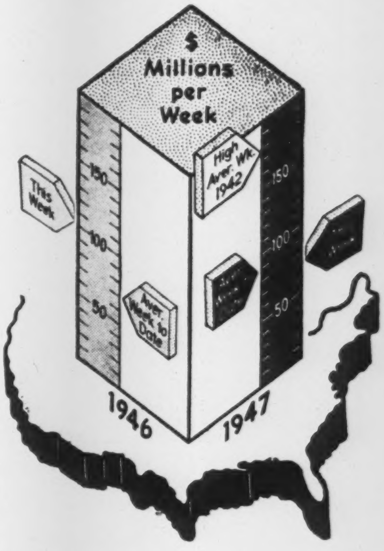
A native of Oxford, Miss., General Sultan attended the University of Mississippi from 1901 to 1903, and then was appointed to the U. S. Military Academy at West Point, from which he received a degree of bachelor of science and his Army commission in 1907. In 1916 and 1917 he served in the Philippines with the Corps of Engineers, and during the first world war he was a colonel on the General Staff.

Between the two wars General Sultan rose to permanent brigadier general and served in various commands.

Noted in the Army as an administrator, General Sultan lived up to his reputation when he entered the C.-B.-I. theater under the late Gen. Joseph Stilwell. One of his chief assignments was the establishment of land, river, pipe and airline communications to increase the flow of supplies to China.

He succeeded and his success was recognized by the Chief of Staff, General of the Army George C. Marshall, with a third oak-leaf cluster to his Distinguished Service Medal, equivalent to a fourth D. S. M. He was the first man in the Army ever to win this decoration four times.

CONSTRUCTION ACTIVITY



As Reported this week to . . .
Engineering News-Record

CONTRACT VOLUME

Continental U. S. Only
(Thousands of Dollars)

	Week of Jan. 23 1947	Cumulative 1947 (4 wks.)	Cumulative 1946 (4 wks.)
Federal	$1,269	$17,854	$36,816
State & Mun.	22,522	89,039	56,356
Total Public.	$23,791	$106,893	$93,172
Total Private	50,083	229,563	184,908
U. S. Total. .	**$73,874**	**$336,456**	**$278,080**

WHERE CONSTRUCTION ACTIVITY ORIGINATED THIS WEEK

Dollar Volume (Thousands)

Type of Work	This Week	Cumulative 1947 (4 wks.)	Cumulative 1946 (4 wks.)
Waterworks	$1,017	$14,342	$4,011
Sewerage	1,900	6,992	2,189
Bridges	2,152	8,093	8,004
Highways	9,203	31,024	27,151
Earthwork, Waterways	1,032	5,838	26,926
Buildings, Public	5,763	21,076	18,677
Industrial	19,180	64,265	78,814
Commercial ..	29,333	155,237	96,760
Unclassified	4,294	29,589	15,548

NOTE: Minimum size projects included are: Waterways and waterway projects, $22,500; other public works, $40,000; industrial buildings, $55,000; other buildings, $205,000.

NEW PRODUCTIVE CAPITAL

	Cumulative 1947 (4 wks.)	Cumulative 1946 (4 wks.)
NON-FEDERAL	$84,270	$92,466
Corporate Securities	1,720	45,811
State and Municipal	82,550	46,655
FEDERAL	....	158,320
Total Capital	**$84,270**	**$250,786**

ENR INDEX NUMBERS

Index Base=100		1913	1926
Construction Cost..	Jan. '47	381.68	183.47
Building Cost.....	Jan. '47	288.78	156.11
Volume	Dec. '46	207	91
SIX UNITS			

EDITORIALS

VOLUME 138 NUMBER 4

January 23, 1947

Ways to Cut Highway Costs

IN THE SPECIAL HIGHWAY SECTION of this issue are statements of experience with highways cost trends during the past year from ten widely scattered states. All reflect the great increases that have occurred in relation to prewar prices. Less clearly indicated is a leveling of costs around current prices, and some observers see signs of a slight downward trend. But whatever the trend, it is obvious that overall costs are going to continue high in relation to prewar levels, which means that more consideration should be given to ways for cutting costs. That fact gives special significance to economies that were practiced successfully during the year by some of the state highway departments, as reported in these pages. Costly hand operations, such as rubbing exposed concrete surfaces with abrasives, were eliminated, small concrete structures were redesigned to facilitate the greatest possible reuse of form panels, structural details were simplified, more attention was given to the wider use of mechanical equipment, large contracts were broken-down into smaller ones which could be completed in a short time and during the latter part of the year, paving contracts for the new year's work were let to permit contractors to stock-pile materials and assemble equipment during the winter months. Continued restudy of designs, work methods and specifications to see where time and money can be saved at no sacrifice of quality should pay substantial dividends.

Sanitary Engineers and Housing

REFLECTIONS on the role of the sanitary engineer in the field of housing, presented by Prof. M. Allen Pond, of Yale University, at the ASCE meeting last week and abstracted elsewhere in this issue, were not based on academic contemplation alone. His very practical outline of the ways by which the special talents of the sanitary engineer could be utilized for the improvement of housing reflected experiences gained during the war. As an officer of the U. S. Public Health Service assigned to housing developments, he saw at first hand how site selection and modification of design and construction could make great differences in the "liveability" of housing from a hygienic standpoint. In pointing to the pattern of cooperation that was developed during the war between sanitary engineers in consultation with planners, architects and builders, Professor Pond properly raises the question: If this was possible under emergency war conditions, is it not even more desirable now as we embark on a vast program of permanent public and private developments? Obviously, there are many aspects of housing that would be benefitted as a result of sanitary engineering counsel. The proposals made by Professor Pond call for sympathetic response from the building industry.

Extending Soils Knowledge

ENGINEERS and construction men, impatient with soil-mechanics research results not immediately applicable in the field, should be gratified with the Navy-sponsored tests on flexible bulkheads currently under way at Princeton. As reported to the American Society of Civil Engineers last week, the tests have shown the value of a sand fill interposed between a hydraulic clay fill and the steel sheetpiles, have fixed its volume as that which will stand at normal angle of repose sloping back from the sheetpiling, and have indicated that no pressure relief on the bulkhead can be expected from vertical arching in the sand. These are results that can be used in practice. One further basic fact is still under study—the necessary width of berm on top of the sand fill to develop its full strength under surcharge loads. With this established, engineers should be able to improve flexible bulkhead design, minimizing failures and perhaps effecting economies. For thus extending soils knowledge, Professor Tchebotarioff of Princeton and the engineers of the Bureau of Yards and Docks who are working with him deserve the thanks of the profession.

Why 1940 Prices?

THE YARDSTICK for measuring contractors' bids on highway construction since V-J Day has resided in the question, "Do they compare favorably with 1940 prices?" Changed conditions, however, warrant examination of the present propriety of this measure. Without doubt, in a period of many uncertainties, it served as a good working tool by establishing, on the one hand, a uniform basis for comparing unit prices offered by contractors who had little knowledge of what their construction costs would be and, on the other hand, a bench mark to which engineers' estimates could be referenced. Now that we have completed a full calendar year of postwar highway construction, however, most contracting agencies have a fair to accurate knowledge of what constitutes reasonable unit contract prices. Moreover, most contractors have some rather definite information on what their construction costs will be. Under such conditions comparisons with 1940 prices lose much of their value, and worse still result in such large percentage increases—as described in detail elsewhere in this issue by ten state highway departments—as seriously to threaten execution of the 1947 highway program. Accepting the fact that highways no longer can be built at per-mile costs anywhere near those prevailing in 1940, would it not be better to substitute 1946 prices as a basis of comparison for bids received during 1947? Such action would simplify the preparation of both bids and estimates, and should aid in holding the line against future rises in unit prices.

Ten Years of the Bay Bridge

In the ten years since ferry boats gave way to the San Francisco-Oakland Bay Bridge, transbay traffic has developed to such an extent that where there was no roadway before, now nine traffic lanes are sometimes overloaded during rush hours. This rush-hour traffic has been increased enormously by factors that the designers did not foresee. Chief among these is a great increase in the number of people who use private automobiles in preference to mass transportation facilities.

The significance of this trend extends far beyond the San Francisco region. It should be taken into consideration by those who plan for freeways through congested regions as well as by the planners of bridges across water barriers like the San Francisco Bay. A new facility always generates additional traffic, and it may effect changes in types of traffic. Either may result in the necessity for building a parallel bridge or freeway; and it may then be discovered that a quite different location for the initial project should have been chosen.

Under proper long-range planning, the first project to be built should be related to others that future developments may make necessary. In this way the first-built facility will serve adequately for a much longer period than it otherwise would. And it will fit properly into any future traffic pattern. The history of the Bay Bridge lends support to such a contention.

Swollen Engineering Schools

Readers of this journal undoubtedly have been impressed with the fact that there are record-breaking enrollments in all of our engineering schools, and that perhaps a third of the total are in the civil engineering departments. Of course, the majority of these students are veterans, and most of them are in college largely because of the educational aid features of the G-I Bill of Rights. But why do so many of these young men choose engineering as their life work? Is it simply due to the wartime prestige of all technical endeavor or are there more fundamental reasons?

Engineering curricula with their emphasis on mathematics and other exact sciences are not easy. Nor can the hope of large future financial rewards be a prime consideration in the choice of this profession, for the civil engineer earns only an average income.

It is probable that there is a certain glamor about civil engineering; our big projects inspire the would-be engineer and stimulate his imagination. But it is also certain that many of these students are convinced that an engineering career offers something really worthwhile, that in sanitation, highway work, water supply, irrigation, flood control, municipal service, or bridge and dam building there is ample scope for his best efforts in the public service. Those who have practiced in the field of civil engineering and construction know that there has been a basis for such conviction in the past. They will likewise want these young men to find justification for it in the future.

The best insurance for such a happy outcome is to have jobs waiting for those students who make the scholastic grade to graduation. There will be more graduates. There must, therefore, be more jobs, not only in booming times but continuously. It is not too soon for the profession to start thinking and planning for the future of these young men.

ENGINEERING NEWS-RECORD

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Airport Fill on Soft Bottom Controlled to Avoid Mud Waves

Contents in Brief—*In making a 6,000,000-cu. yd. fill at the San Francisco Municipal Airport, careful control of depth was necessary to adequately consolidate underlying mud without building up pressures that would produce excessive mud waves. The fill, part of a $20,000,000 airport expansion project, was placed at rates as high as 1,000,000 cu. yd. per month.*

CAREFUL REGULATION of initial depth on a 6,000,000-cu.yd. earth fill, made in expanding facilities at the San Francisco Municipal Airport, was used to obtain maximum consolidation of the underlying bay mud with a minimum of fill material. By use of a specially built $500,000 haul road the fill was advanced at rates as high as 1,000,000 cu.yd. per month.

The municipal airport is located on the bay shore some 15 miles south of San Francisco's business district. More than 20 years ago a runway suitable for what would now be considered light planes was constructed on marsh land at this location. All of the several expansions since then have required fill, either dredged or dry, on bay mud. The latest and largest fill contract, described in the following, will practically complete the expansion program.

Airport history

Development of this airport from a one-runway field to the extensive air terminal now under construction constitutes a record of one municipality's endeavor to keep up with the progress of aviation. Because San Francisco is located on a hilly peninsula, there were few areas available suitable for an airport. Even at the location chosen the only way to obtain the area ultimately needed was to make an extensive fill on tidal mud flats. Successive steps in making this fill are shown in Fig. 1. With each expansion project, the runway pattern was altered. The first extension was undertaken some 15 years ago, the second 8 years ago, and the third during the recent war.

From the very outset, expansion of this airport to the west has been prevented by the fact that the western boundary has been a four-lane major highway. However, this highway is now being relocated and rebuilt as a freeway about half a mile farther west. Additional space thus made

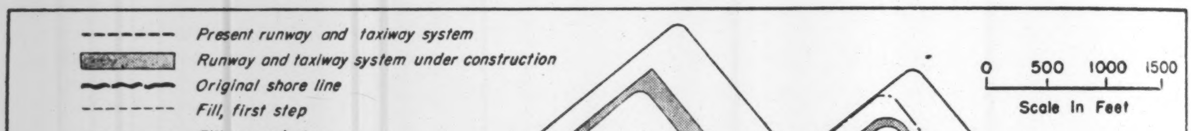
Present runway and taxiway system
Runway and taxiway system under construction
Original shore line
Fill, first step
Fill, second step
Fill, third step
Fill, present construction
0 500 1000 1500
Scale in Feet
Coast Guard Air Station
United Airlines Area
Present Administration & Hangar Area
New Administration Area

Fig. 1. Each successive step in expanding the San Francisco Municipal Airport has required fill on bay mud. An entirely new pattern of runways will result from the current construction program.

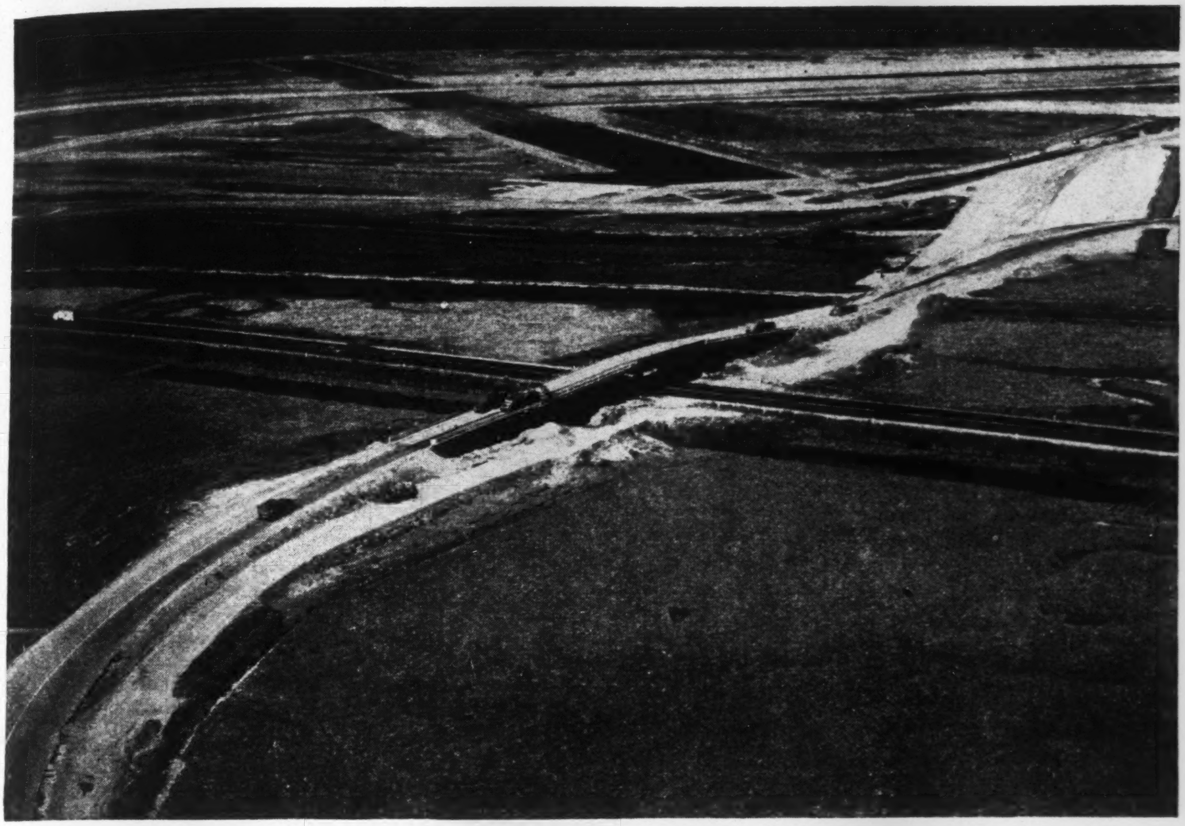

Fig. 2. A $500,000 haul road, built expressly for this airport job, required the construction of three major overpasses.

available to the airport will be used for hangars, shops, administration area, etc.

The current airport expansion program includes a new administration and hangar area to replace the existing facilities, which with minor revisions and expansions have been in use for more than two decades. In addition to providing a modern air terminal for domestic air lines, a new port of entry will be available for traffic from overseas. Most of the area to be available for lease to commercial air lines for their shops, etc., has already been allocated.

Filling on soft mud

The chief problem in this final step in the airport development was the matter of obtaining a safely compacted, stable fill in an area covered by water over a soft mud bottom reaching to a depth of minus 80 ft. in places. To assure this result, the fill had to be placed in such a way as to avoid trapping any of the soft bay mud in pockets. It was not economical nor was it necessary to excavate in advance of the fill so long as filling operations could be conducted in such a way as to squeeze out fluid mud and adequately compact such mud as remained.

The technique in attaining this objective was to so place the fill as to squeeze out undesirable material as the fill progressed. Much of the fill was placed in an area enclosed on three sides, the fourth side being open toward the bay. Filling started at the bottom of the "U" thus formed and gradually advanced toward the open side, forcing the fluid mud ahead of the fill.

In addition to the fluid mud, much of the moisture in the mud left in place was squeezed out. Once a desirable "mud wave" was started by such a procedure, it was necessary to keep it moving and hence a slight surcharge (Fig. 3) was maintained along the forward edge of the fill. This surcharge also served as a dike for protection against high tide (El. 9.4).

The principle of keeping this small mud wave moving was so important that specifications required that the fill face advance at least once every working day and that during idle periods (weekends or holidays) concentrated loads be left on the edge of the fill. These concentrated loads were formed by dumping fill near the edge without spreading it with bulldozers. Had the mud wave been left to consolidate, it might have been filled over, leaving a bulge of mud in the fill. Then, when finish grade was reached the increased settlement at the point of the bulge would cause soft spots in the runway.

Two kinds of mud waves

Although it was necessary to have enough fill to consolidate the underlying mud and advance the desirable, moderate mud wave, if too great a layer of fill material had been placed, the shearing strength of the mud would have been exceeded and large sections of the fill would have slid into the bay in a deep, undesirable wave of mud.

The finished grades ranged up to El. +13.0, but the limit of the first fill layer was El. +8.0 or +8.5. This limit was based on experience with previous fills in this area on similar mud bottoms. By carefully controlling the fill within these limits, the moisture content of the underlying mud was reduced and a greater shear value obtained. This, together with the confining action of the fill already placed, made it possible to build up to finish grade without forming a second or deep mud wave of the objectionable sort.

The second increment of fill brought the surface up to only 30 in. below finish grade. All fill below this elevation was compacted to at least 90 percent of AASHO standard density through the action of the heavy earthmoving equipment moving over the surface. The route of this equipment was varied from time to time to compact the entire fill area.

The final 30 in. was required to be 95 percent density and was compacted with the aid of sheep's-foot rollers.

Before the work started, penetration of the fill into the bay mud was expected to be some 5 ft. By carefully regulating the fill depth, however, this penetration was kept down to some 3.0 to 3.5 ft. City officials expect the entire fill to settle 0.8 ft. in the first year and after that about 0.03 ft. per month.

The contract called for completion of the 6,000,000 cu.yd. of fill in 250 days. The bid price was 62.3 cents per yard. As all the fill had to be hauled some 3 miles, an outstanding organization job was necessary. With four months' time remaining, as this was written, the contractor expected to complete the fill work two months ahead of schedule, barring heavy early rains. Fill was placed at a rate of more than 1,000,000 cu.yd. a month. Maximum fill for a 24-hr. period (three shifts) was some 46,000 cu. yd.

Much equipment used

The equipment used to obtain this volume included an average of about 75 trucks or other high-speed earthmoving machines, three 6-yd. electric shovels and three 2½-yd. diesel shovels as well as other miscellaneous equipment such as bulldozers, a well-drilling rig for blasting, sheep's-foot rollers, etc. The electric shovels were powered by 2,300-volt lines from a central bank of transformers. The earth-moving equipment included the following bottom-dump types: 21 with 33-yd. capacity, 20 with 16-yd. capacity, and 36 with 13-yd capacity. The two larger sizes are of postwar design and were used for the first time on this job. Each truck hauled an average of 20 loads per shift over the 3-mi. haul road.

This haul road, costing some $500,000, was constructed to expedite the work. It crossed two major highways, a double-track main line railroad and a double-track streetcar line, requiring three plate-girder-type, overpass bridges and utilizing the following materials: 450 tons of steel, 9,000 b.ft. of lumber, 300,000 cu.yd. of earth fill, 20,000 tons of crushed rock base, and 7,000 tons of plant mix asphalt surfacing.

The road was surfaced with 6 in. of rock and 3 in. of asphalt. White lines were painted on it for traffic control in accord with main highway practice. In spite of the paved surface, some dust accumulated on the road surface. As a means of combating this dust, the contractor made periodic applications of calcium chloride as well as lightly sprinkling the road surface with water.

Borrow pit 3-miles away

A sidelight on the contractor's outlay for borrow pit and haul road is the prospective future use of these facilities on other contracts. When the airport fill was about 70 percent completed, this same contractor was successful bidder on the 5-mi. highway relocation to the west of the air-

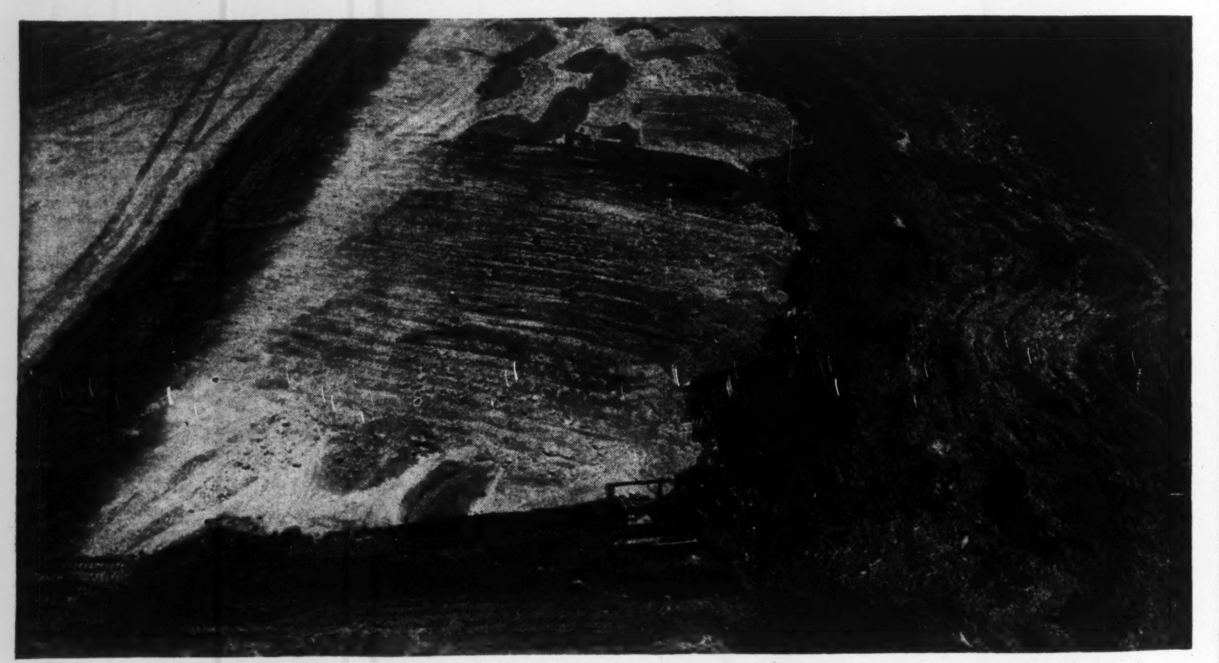

Fig. 3. Many bulldozer-equipped tractors similar to those two spread the fill material left by the large capacity earthmoving equipment. This is a key operation in getting maximum consolidation of the underlying mud with minimum fill material.

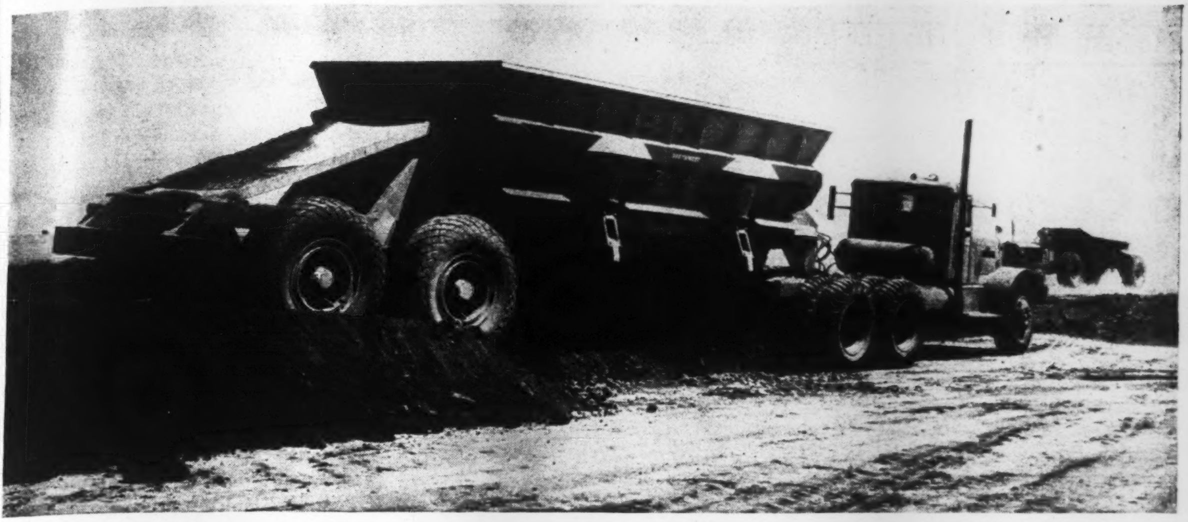

Fig. 4. Large earth movers carrying some 33 cu.yd. of fill, which were first used on this job, were key pieces of equipment.

port, a job calling for some 2,000,000 cu.yd. of fill that can be hauled from this same pit, making use of all but half a mile of the haul road.

The fill material specifications called for minimum Cal-bearing of 20, maximum swell 1½ percent. The material used is a very fine sand of which 35 to 50 percent passes a 200-mesh screen.

It was obtained from a nearby pit where some 14,000,000 cu.yd. was available. Shovels working at the foot of a 260-ft. face could have excavated all of the material without the aid of blasting. However, for safety reasons this 260-ft. cliff was broken away in a two-shelf pattern.

To accomplish this a well-drilling rig working on the top of the face would first drill holes some 60 ft. deep. The effect of the blast would usually carry a shelf down an additional 20 ft. for a total of 80 ft. This shelf was then cleaned off by a bulldozer. The well-drilling rig would then move down to the shelf and repeat the process. This left, at the bottom of the 260-ft. face, an unblasted height of only 100 ft. which the shovels could safely dig away. One well-drilling rig was able to keep up with the shovels by doing the blasting twice a day between shifts.

Drainage

Drainage has been a major problem in design and construction at this airport. Some of the existing facilities, such as aprons and taxiways, are at levels as low as El. +5.0. The low point of the new runway and taxiway system will be at El. +7.0. The high point of the new construction, a point on the runway system, will be at El. +13.0. The tidal range is from El. −2.0 to El. +9.4.

The drainage problem is made difficult by the fact that the low part of the runway and taxiway system is on the inshore side below high tide. To add to the problem, provision must be made for drainage from the foothill area west of the field. This latter will be taken care of by a drainage canal along the entire western side which will intercept the runoff leading to ponding areas during the periods of high tides. The ponding areas in turn will be controlled by automatic tide gates.

Two methods will be used to drain the field. One employs ponds between runways which are drained by pipelines with flap valves at El. +6.0 (3.4 ft. below high tide). The other method is the usual system of underground terra cotta and concrete pipe drains. All drainage design is based on a 100-yr. rainfall record of 0.5 in. per hour for 5 hours.

The contract for the 6,000,000-cu.yd. airport fill is held by the Macco Corporation and Morrison-Knudsen Company, as joint contractors, for which O. H. Tucker is project manager and George Haensel, superintendent. Design of the airport expansion is being done by the Power and Utilities Engineering Bureau of the city of San Francisco, A. O. Olson, chief engineer. Construction engineer for the city is Adolph J. Wehner.

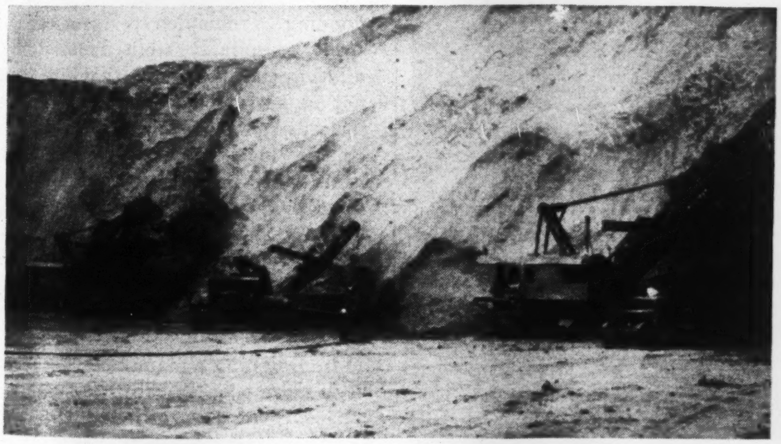

Fig. 5. Three of the six power shovels working in the pit, load fill material. Shovels and earth-movers worked on a three-shift basis.

Carbon-Dioxide Fire-Protection Systems

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Contents in Brief*—It is more economical and efficient to include fire protection in the original plans for a building than to install it years after the structure has been completed. When carbon-dioxide systems are used, they can be either manually operated or automatic and either of the "total-flooding" or "local-application" type, depending upon whether the hazard can be inclosed. Factors to be taken into account include appearance, ventilation, shutting down of electrical equipment, and housing of cylinders.*

MANY FIRE HAZARDS in industrial plants, especially those involving the use and storage of inflammable liquids, require an engineered carbon-dioxide fire-protection system. In the past, these systems often have been installed after the manufacturing plant was constructed, but preplanning can result in substantial reduction of costs and increased efficiency in protection.

To plan for carbon dioxide systems, it is first necessary to know what they are, how they work and how they are installed. The type most generally found throughout industry is the high-pressure system. This consists of one or more steel cylinders containing a 50-lb. charge of carbon dioxide in liquid form under pressure of about 850 psi. at 70 deg. (Fig. 1). Standard cylinders are 51 in. high, have a diameter of 8½ in. and weigh about 165 lb. fully charged. Galvanized steel pipe and extra heavy galvanized malleable iron fittings are used in conveying the carbon dioxide from the cylinders to the nozzles, which are located at the hazard.

When released, the carbon dioxide rushes under its own pressure through the piping and out the discharge nozzles, where in gaseous form it expands to 450 times its stored cylinder volume. This tremendous quantity of carbon dioxide reduces the air's normal 21 percent oxygen content generally to around 15 percent, thus "smothering" flames in a matter of seconds. The nature of the hazard largely determines the amount of carbon dioxide required and the extent to which the oxygen need be diluted.

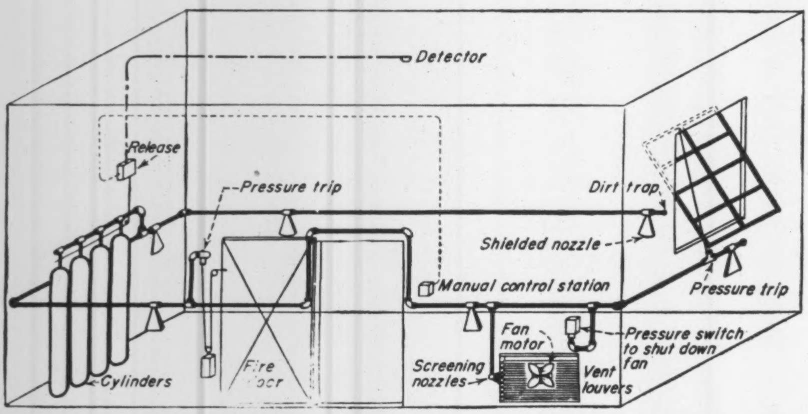

Fig. 1. Diagrammatic layout of a total-flooding installation. The pressure of the carbon-dioxide gas actuates trips to shut the window, close the fire door and shut down electrical equipment.

Types of carbon-dioxide systems

Systems can be either manually operated by a pull handle or automatically operated by means of one of several types of fire detectors and automatic releases. Automatic systems, usually supplemented by an emergency manual release located at a safe distance from the hazard, are of several approved types: electric thermostat and solenoid releases, fusible link, or pneumatic (rate-of-rise-of temperature) systems. In this last method a sealed air bulb is connected by tubing to a diaphragm in the releasing mechanism, which in turn trips a series of levers to release the carbon dioxide.

There are two main types of carbon dioxide installations. The first and most economical, called "total flooding", completely protects a space reasonably well inclosed, by diluting the oxygen so that fire cannot be sustained in any part of the inclosure (Fig. 1). The second type, called "local application", protects against fire hazards that are not confined by walls or other inclosures (Fig. 2). Here, carbon dioxide is concentrated at the fire hazard, and nozzles are strategically placed to cover every square foot of the hazard area.

In designing a manufacturing plant it is more economical to arrange for inclosure of a hazard so that it can be protected by totally flooding the entire area than to use a local-application system. Thus, where possible,

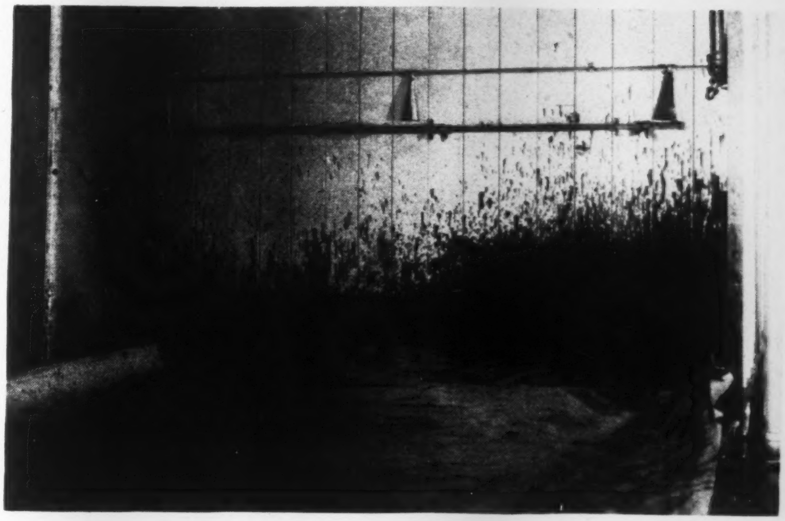

Fig. 2. Local-application systems are useful in protecting uninclosed spaces, such as the above dip tank containing an inflammable liquid.

Fig. 3. Heavy steel panels suspended over the louvered windows of a transformer vault will drop and cut off the air supply when the released carbon dioxide actuates a pressure trip. Similarly, doors will be closed.

local application should be kept to a minimum.

Total-flooding systems are primarily based on the volume of and the nature of the contents in the inclosure. This space together with the related openings, such as windows and doors, dictates the size of the system. One 50-lb. capacity cylinder will protect a space up to 300 cu. ft. Larger volumes will, of course, require more carbon dioxide, although not proportionally so much.

Nozzles are attached to the walls or ceilings of the enclosed area, the number and type depending on the structural details and contents of the space. The piping joining the nozzles and the cylinder batteries, which in most cases are placed outside the protected area, is generally clipped to the walls in the standard manner.

Since total flooding of a space is predicated on the tightness of the inclosure, any source of fresh air supply, such as doors, windows, fan openings and ducts, must be either closed, dampered or screened by carbon dioxide so that air cannot enter. To accomplish this, the pressure from the carbon-dioxide piping is used to actuate tripping devices to drop dampers or release doors and windows (Fig. 3) as well as to actuate pressure switches to cut-off ventilating systems and stop electrical equipment.

Where tripping of doors and windows is not feasible, a screening blanket of carbon dioxide is thrown across openings to dilute any oxygen infiltration. The amount of screened area permissible should not exceed about 3 percent of the inclosed volume. When it does, a local-application system should be used.

Protection of open areas

Local-application systems can be used where little or no inclosure for the hazard is available. Nozzles are placed so as to cover all exposed surfaces of the hazard area. A good example of an application of this type of protection is in the case of a dip tank and drain board area (Fig. 2) used with highly inflammable liquids, such as paint or enamel.

Some considerations in planning carbon-dioxide systems are:

1. Subdivision of hazardous areas results in fewer cylinders, since a central battery of cylinders with automatic distributing valves is most economical.

2. The inclosing of open hazards, where feasible, will convert the local application type into the more economical total flooding type.

3. In assigning necessary space for a cylinder battery and distributing valves, it should be noted that where cylinders will be exposed to outside elements, suitable inclosures for protection from the weather are needed.

4. In determining the location of automatic releasing devices, it is sig-

nificant that the use of self closing doors, windows and dampers in original construction results in savings over later changes or use of special devices. Where electric equipment, such as fans and motors, are to be shut down, holding coils and relays must be used for equipment beyond the capacity of the carbon-dioxide pressure switch.

5. Where automatic protection is desired, proper consideration should be given to ventilation and ceiling beam details, all of which affect detector locations and their connections.

6. Where special explosive hazards exist, the purchase of pressure relieving self-closing windows and other equipment can be foreseen and savings effected.

7. Where the need for streamlining or appearance calls for concealing the piping in the walls or ceiling, arrangements should be made in advance in order to dovetail construction with installation of the system.

Supreme Court Makes Finding Unfavorable to General Contractors

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THE DECISION of the United States Supreme Court, rendered November 26, 1946, in the case of *United States* v. *Howard P. Foley Company, Inc.*, is of very considerable interest to all contractors having dealings with the Federal government.

The Foley Company had recovered a judgment in the Court of Claims (105 C Cls. 161; 63 F. Supp. 209) for the increased costs occasioned it by the failure of the government to permit it to perform a particular contract undertaking in an orderly way and within the time agreed. It had contracted to install a field-lighting system at the National Airport near Washington within 120 days from date of receipt of notice to proceed. It had the force and equipment to perform as agreed but because of the fact that after it was ordered to proceed the government encountered unexpected difficulties in completing work necessary to be done before Foley's work could be performed, the contractor maintained its organization on the work for 157 days beyond the expiration of the time, 120 days, within which the work was contracted to be performed.

The Court of Claims held—and the holding surely would appear to be fair and reasonable—that inasmuch as the government *fixed* the contract time, with heavy liquidated damages for any delay *by the contractor* in completing on time, it certainly was to be assumed that it, the government, would not by any act or failure to act on its part, make it impossible for the contractor to perform as agreed, and rendered judgment for the cost of prolonged supervision of the work.

On review by the Supreme Court, the Court of Claims was reversed.

The Supreme Court said that "in no single word, clause, or sentence in the contract does the government expressly covenant to make the runways available to respondent at any particular time". It went on to say that even if the provision obligating the respondent to complete his job in 120 days could not be stretched to mean that the government obligated itself to ever use the highest degree of diligence in efforts to make the runways available, the facts of this case would show no breach of such undertaking.

The crux of the Supreme Court decision is in the first paragraph as follows:—

> "The Court of Claims rendered a judgment for the respondent and against the government for an asserted breach of a construction contract. 63 F. Supp. 209. We granted the government's petition for certiorari which alleged that the Court of Claims' decision was in direct conflict with *Crook* v. *United States*, 270 U. S. 4, and *United States* v. *Rice*, 317 U. S. 61 (1CCF 396). We hold that the government's contention is correct."

The Court of Claims had been careful to point out the differences of fact between the Crook and Rice cases and the Foley case. In the Crook case (and similarly in the Rice case) one took a *contract* (not a "subcontract" as the Supreme Court mistakenly states) to install heating and other equipment in a building which *another contractor* had contracted to build. Other large and vastly more important work (a drydock) was in course of performance by other contractors in the immediate vicinity and it was known by all—and the contract so provided—that the progress of one work was interrelated with the progress of the others and a delay on one would necessarily delay the others. In the Foley case no such situation existed. Other contracts were not involved—the United States itself was buildings the runways, etc., on which the Foley lighting was to be installed. When it gave notice to proceed it was equivalent to saying: "The site is ready for your work." The site was not ready except for small parts and was never ready continuously, only in isolated parts.

The Supreme Court brushes these distinctions of fact aside as unimportant and says:—

> "If this be a distinction, it is a distinction with no significant difference. This contract, like the others, shows that changes and delays were anticipated and provided for. The question on which all these cases turn is, did the government obligate itself to pay damages to a contractor solely because of delay in making the work available? We hold again that it did not for the reasons elaborated in the *Crook and Rice* decisions."

The writer has always thought that the Crook decision was predicated on a misconception of the facts. He is even more sure that the Foley ruling is similarly misconceived. Both overlook a basic consideration that the government when it contracts with its citizens is to be fed out of the same spoon as any other contractor. What is binding on the one should be binding on the other. These decisions appear to accord to the government as a contractor privileges never accorded to a private contractor.

If these decisions are not good law, the courts will in time come around to a more correct rule. Meanwhile, when contractors enter into a contract with the federal government for work on which similar delays are possible, they should make certain that the contract protects them against loss due to such delays.

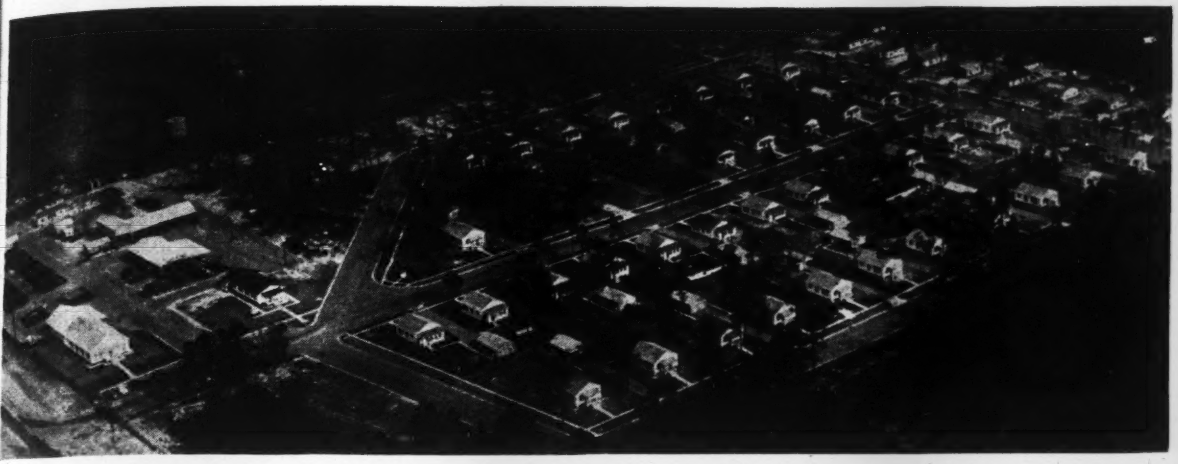

Fig. 1. Typical of model camp construction by the Humble Oil and Refining Co. is its new camp at Conroe, Tex.

Model Camp Construction in the Oilfields

Contents in Brief*—Improved designs for prefabricated four, five and six-room cottages now being built in model oilfield camps of the Humble Oil and Refining Co. are based on extensive research and interviews of employees on living facilities desired. Rental rates are maintained at prewar levels, despite increased cost of construction.*

FOUR-ROOM HOUSES that rent for $12 per month—five rooms for $15—and six-room houses each containing three bedrooms, two baths, a dining room, living room, and a large kitchen, that rent for $18 per month; a rent free garage goes with every house and installed facilities provide gas for cooking and heating at $1.00 per month, electricity at 2c. per kwh., with no charges for water, sewage service, or for garbage collection and disposal.

No, this is not a house-hunter's dream, but a reality in some 300 company-owned communities provided by the Humble Oil & Refining Co., for its employees. Starting late in 1944, the company now is nearing the completion of its $2,500,000 housing construction and repair program for all Humble Co. camps, located principally in Texas and Louisiana. The 1945 schedule includes 211 new houses, while the 1946 program increased that total to about 500 completed dwellings.

Model camp construction is not a new venture for Humble—for the past several years the company has been providing low-rent community dwellings for its employees engaged in drilling new fields and in operating producing wells. Under the recent improvement program, however, a large amount of research was involved in providing homes that furnish a maximum of comfort and convenience.

Employees suggest improvements

Many ideas for improvement were obtained from interviews with employees' wives who had lived in company-owned houses for several years. In general, they were willing to sacrifice kitchen space for additional closet space. Moreover, they wanted some arrangement made for serving breakfast in the kitchens since their husbands usually leave for work early in the morning. As a result, the company devised a portable utility cabinet equipped with a disappearing shelf which can be pulled out to form a table top. This cabinet now is included as standard equipment.

During an expansion of the Katy Gas Plant near Houston, Tex., the company erected a five-room house, incorporating several suggested changes in layout and design. Some 45 workmen's wives were invited to inspect the new house, with the result that 32 approved it in all respects, eight offered a few criticisms and the remainder made no comments. Previously, the company had erected houses at this plant containing three differently arranged kitchens. A vote by the Katy housewives showed almost universal approval of one of the kitchen floor plans. This plan was promptly incorporated as standard in all new houses.

It was by these methods that new standard house plans were worked out for official approval. These new plans formed part of the background work for the current building program and they have been adopted for all company camp construction in the immediate future.

Model camp at Conroe, Tex.

A good example of the quality of housing that Humble provides for its employees in more or less isolated localities is found in the recently completed 52-house community at Conroe, Tex., which was erected at a total cost of $550,000. Here live some 180

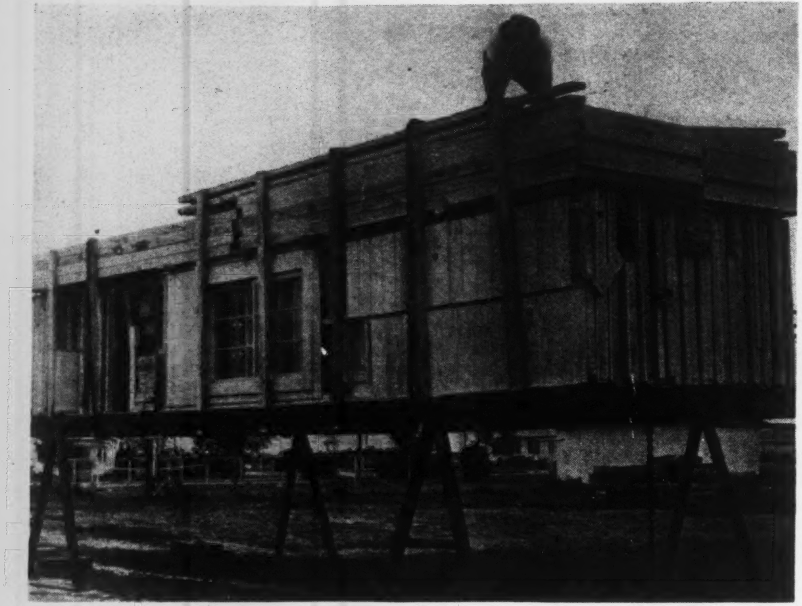

Fig. 2. Prefabricated in 4-ft. modular length sections, the houses were trucked to the site in packaged assemblies of one-half house each.

people connected with the Humble Oil and Refining Co. production department, and the district headquarters of the Humble Pipe Line Co.

All construction at Conroe was done by contract, in keeping with the company's policy on camp construction. The cottages, garages and utility buildings were prefabricated not only to reduce costs through standardized construction but to minimize the amount of on-the-job erection labor, which was in serious short supply. They were fabricated in 4-ft. modular length sections to facilitate future dismantling, moving and re-erection should the need arise to shift part of the camp to some other location.

All houses have an 8x20-ft. glazed-in porch extending almost completely across the rear and a 6x12-ft. open porch in front. The four-room cottage contains two bedrooms, bath, living room and a combination kitchen-breakfast room. The five-room house is similar in design except that it has a dining room.

A double garage serves each pair of houses and twin wash or storage rooms are located at the rear of each garage. Storage rooms are equipped with hot and cold water, overhead electric lights and concrete floors that drain to sewer lines.

In addition to the cottages, suitable dormitories were provided for single workmen and rent-free lots, complete with all utility connections are availabe for employees desiring to build their own houses. The company even finances the construction of such privately-owned homes, at a nominal interest charge.

Located in one corner of the Conroe community is the industrial section. This includes a warehouse, loading docks, pipe racks, repair garage, machine and electric shops, grease room, garage for trucks and equipment, bath house for the men to clean up after coming off the job, and a recreation hall. These are standard installations at all larger district camps.

Houses are attractive

Although prefabricated, the four, five and six-room cottages are unusually attractive in appearance. They are painted white and have green asbestos shingled roofs. Except in the bathroom and kitchen which have inlaid linoleum on plywood, all floors are oak, on 1-in. subflooring, with an intervening layer of 15-lb. saturated felt for insulation. Floors are carried on longitudinal 2x6-in. joists on 24-in. centers, supported on transverse 4x6-in. sills spaced 6 ft. apart. Each sill rests on concrete block pedestals spaced 6 ft. apart and extending about 14 in. above the ground. This open foundation is employed where possible as a protection against termites.

At Conroe, each concrete block pedestal is topped with a 26-gage metal termite guard. In the northern part of Texas where the winters are more severe asbestos siding often is used instead of timber siding, and creosote-treated timber posts are used in lieu of the concrete block pedestals to permit carrying the siding clear to the ground. When the skirting material is timber, it is impregnated with Wolman salts or chromated zinc chloride to resist termites.

Interior walls are of wallboard or ¼-in. plywood on 2x4 studs and exteriors are yellow pine siding insulated with a 30-lb. felt.

As shown in the accompanying floor plan of a typical five-room house,

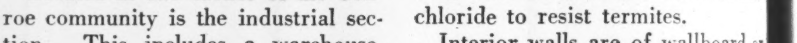

Fig. 3. Ample closet and storage space was preferred even at the expense of kitchen and living space.

each room is of ample size, although not spacious. The living room is 12x14 ft., bedrooms measure 12x13¼ and 12x13½ ft., the dining room is 12x10 ft., and the kitchen 10x9 ft. In addition, each house has ample closet and storage space, a built-in pantry in the kitchen for the storage of canned goods, and an automatic hot water heater usually located on the back porch.

The same meticulous attention to detail, as that evidenced in the construction of houses, was followed throughout the entire construction of the Conroe community. Gas for cooking and heating, and electricity were provided, and a sanitary sewer system was installed complete with septic tanks.

The camp water system consists of a deep, drilled well with a 1,000-bbl. tank elevated on a 60-ft. steel tower, and a pressure distribution system to provide all houses with water.

Streets were surfaced with 36-ft. bituminous asphalt pavement between concrete curb and gutters. Concrete sidewalks were built in front of the houses and driveways to garages are bituminous macadam, with concrete turnouts from the streets.

Fire prevention is important

Since most of Humble's camps are beyond municipal fire protection, extra precautions are taken to guard against this hazard. Typical of such precautions are those to be found in the Conroe community. They include the asbestos shingles on all houses and buildings, and a 65-ft. standard width of building lot to provide extra space between adjacent cottages.

The elevated water tank, together with a 1-in. service line leading to each house and a 50-ft. length of garden hose provided by the company are good insurance against fire. In addition, the company installed a 1¾-gal. chemical fire extinguisher in each cottage, and for every ten cottages there is a fire cart with a 20-gal. extinguisher. These carts, together with fire ladders and axes, are kept in corrugated fire houses centrally located with respect to the houses which they are intended to serve.

Landscaping of the Conroe community, which also is the rule at the other large company communities, was supervised by a company landscape architect. Shrubs and lawns were installed at company expense, but each employee is charged with the responsibility of keeping up his lawn and shubs. In general, the company paints the exterior of its model-camp houses every three years, while the interiors are freshly painted, and floors refinished, as necessary. Garden plots also are provided, rent-free.

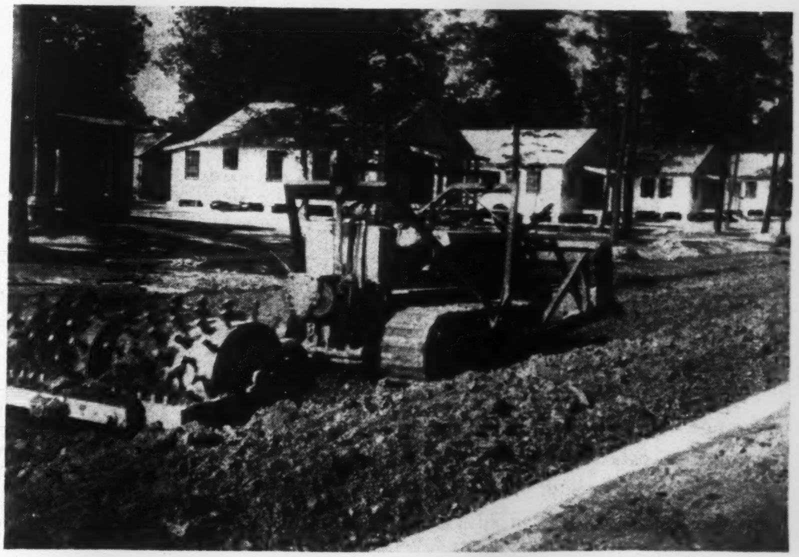

Fig. 4. Open foundations protect the houses at Conroe from termites. Streets were graded, compacted and surfaced with bituminous pavement.

Conroe camp, in fact, is a complete little city, even to a well-designed street lighting system. It has two one-acre playground areas, completely equipped, and a small postoffice building near the entrance to the residential section of the camp. Telephone service is provided in the offices and superintendents' cottages. Bus transportation also is provided to take the children to a nearby school.

Humble Oil and Refining Co. maintains 62 big headquarters communities, similar to the Conroe camp, for its production department; and 58 smaller communities. Humble Pipe Line Co. maintains 64 such camps. In addition, the production department has a number of pumper camps, some of which have as little as one cottage located on a leased area of land and centrally located to the wells the pumper supervises.

Engineering personnel

Responsibility for the design and supervision of construction of all Humble camps rests with the company's civil engineering department, which is headed by S. W. Oberg, chief civil engineer. Dan Mendel was field engineer in charge of construction of the Conroe camp. Houses were fabricated by the Hull Housing Corp. of Houston. Erection of the houses on the site, and street and sewer construction were by Brown & Root Construction Co., Houston, Tex.

Sanitary Engineers' Role Increased in Indiana

Decentralization of state health services in Indiana, which will be effected soon, recognizes the importance of the sanitary engineer in coping with area problems in that state. Five branch offices will be established, each of which will be in effect a miniature state board of health with its director a deputy state health officer for the area.

Personnel of each branch unit will include a sanitary engineer, who will make routine local water surveys and promote installation of new supply and treatment facilities. The engineers will also make follow-up investigations of projects under construction, plans for which have been approved by the central office.

By affording sanitary engineering consultation services to local authorities, the state board expects to expedite construction of public water supplies. It is estimated that 100 towns in Indiana can afford but do not have such facilities.

First Revenue-Bond Bridge Pays Off

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***Contents in Brief**—The Louisville Municipal Bridge, opened to traffic Nov. 1, 1929, initiated the revenue-bond type of financing, since successfully used on hundreds of millions of dollars worth of public works. Its trust indenture was a pioneer instrument upon which most subsequent plans have been based. By taking advantage of low construction costs and decreasing interest rates and by benefiting from greatly increased traffic revenues during the war period, the Bridge Commission has retired all of its bonds and become debt free in 17 years.*

ON NOVEMBER 1, LAST, all tolls were removed from the Municipal Bridge over the Ohio river at Louisville, Ky., signalizing the repayment of all costs of the project out of net revenues collected during the last seventeen years. The event is of particular importance because it was on this structure that the revenue-bond type of financing was introduced to the public works field. Neither public funds nor the pledging of municipal credits was involved in its financing. And although the original toll schedule was moderate it was possible to reduce the toll rates several times as the revenues increased beyond the bond service requirements.

As a pioneer undertaking the Louisville Bridge set precedents that have been widely and successfully followed, showing the way for realization of hundreds of millions of dollars worth of heavy engineering works since 1929, including a large part of the self-liquidating projects built during the business depression of the 1930's. Its development background and financial history, therefore, assume a significance that is worthy of note.

Early financing efforts defeated

The need for better traffic facilities across the Ohio River between Louisville, Ky., and Jeffersonville, Ind., than could be provided by existing ferries first began to be felt in the period following World War I when the state highway systems of Kentucky and Indiana were being developed rapidly. Numerous committees were appointed by local agencies to study the problem, and in 1926 the General Assembly of Kentucky authorized such cities as Louisville to establish commissions to construct, operate and maintain bridges across navigable streams, and to finance them with an issue of general obligation bonds which must first be approved in a local election and eventually be retired from tax collections. This action was quickly followed by the creation of a Louisville Bridge Commission, which selected engineers to make a report on the location and cost of a bridge. A resulting proposal submitted to the Louisville electorate in November, 1926, and involving financing by increase of the local tax rate was, however, overwhelmingly defeated.

A year later, in November, 1927, a proposal to finance with bonds guaranteed by tax funds, but to be retired from tolls collected on the bridge, was then submitted to the voters, but this also was defeated. It was evident that the project must be financed without use or obligation of the city's credits.

The situation had by that time attracted the attention of private interests engaged in financing privately-owned toll bridges with mortgage bonds, along with preferred and common stocks, at large discounts and with high interest rates. Although the commission was averse to such a plan, on the advice of its engineers and others, it determined to receive formal financing proposals from all interested parties, with the thought that a competition of this nature might result in a plan that would be acceptable.

More than twenty separate proposals were received, among them one

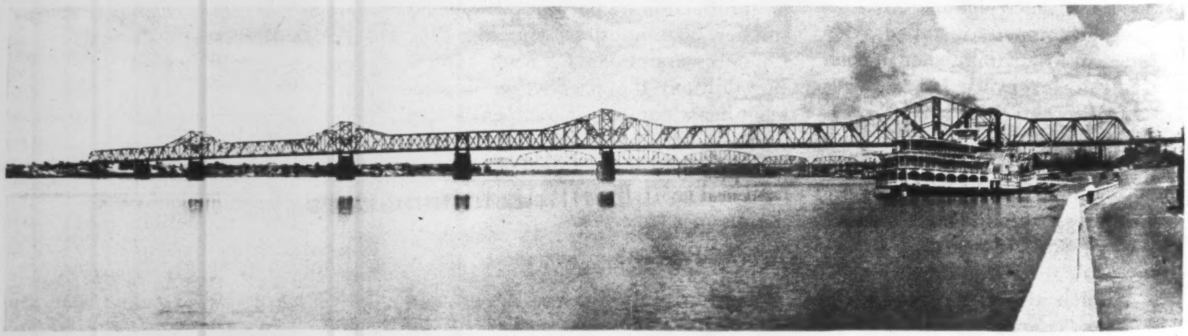

Fig. 1. Louisville Municipal Bridge, completed in 1929 at a cost of $5,500,000, became toll and debt free Nov. 1, 1946.

submitted by Stranahan, Harris and Oatis, a bond house of Toledo, Ohio, which contained some novel and attractive features. Briefly, it was proposed to buy up to $6,000,000 worth of bridge revenue bonds of the City of Louisville at a 4½-percent interest rate, to be secured not by a mortgage on the property, but only by a lien on the net revenues, after the payment of the costs of maintenance and operation of the bridge. The proposal was conditioned upon a traffic survey, to be made by recognized traffic experts, which would show that the estimated bridge revenues would pay the annual costs of bridge operation and maintenance, leaving a net sufficient to pay bond interest and retire the issue in twenty years. And there was added the further condition that an act of the Kentucky legislature be obtained to enable the City of Louisville Bridge Commission to issue and sell such bonds upon the execution of a trust indenture with a trustee bank which, with approval of the consulting engineers, would administer the various funds including the proceeds of the bond sale for construction purposes and, subsequently, the bridge revenues for the service of the bonds.

The firm of Coverdale and Colpitts of New York City made the traffic survey with the cooperation of the consulting engineers to the Commission and found that probable revenues would meet the requirements of a $6,000,000 bond issue. The General Assembly of Kentucky then passed the required enabling legislation, as it had been drafted by Masslich and Mitchell of New York, counsel for Stranahan, Harris and Oatis, in February, 1928.

Trust indenture drawn up

Masslich and Mitchel and the consulting engineers next undertook the drafting of the first trust indenture ever used in obtaining bridge revenue bonds. It established the form of the bonds. It required that the proceeds of the bond sale be placed in a construction fund in the hands of the trustee, and set up procedures for the guidance and security of the trustee in disbursements under the detailed supervision of the consulting engineers in order to assure construction of a sound engineering structure. It established a revenue fund, a sinking fund and a maintenance reserve fund.

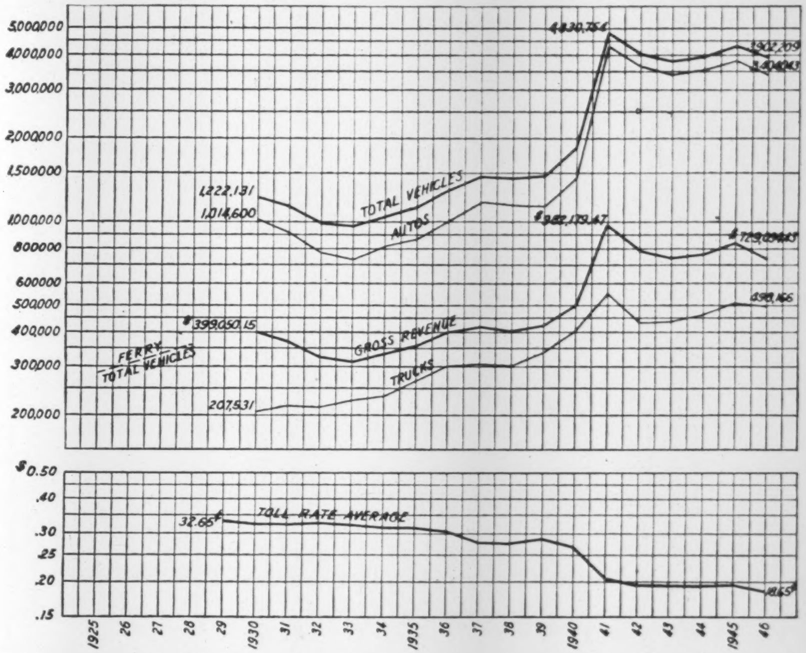

Fig. 2. Variations in traffic, revenue and average toll rate during life of the revenue bonds issued to finance the Louisville Bridge in 1928.

And finally it included covenants of the commission to maintain an adequate schedule of tolls; to keep the structure in a properly maintained condition at all times under the direction of the consulting engineers; and to keep the bridge insured for the protection of the bondholders.

This indenture was completed and executed on May 1, 1928, securing $6,000,000 face value of 4½-percent bonds. Only $5,500,000 worth was sold, however, and this provided the commission with funds to proceed with actual construction. Contracts were awarded promptly, and eighteen months later the structure was opened to traffic on November 1, 1929.

Toll history

Under the original toll schedule passenger automobiles paid a cash fare of 35¢, and commutation rates were available at 20¢ per crossing. Other fares were based on rated capacity of the vehicles, 5-ton trucks paying $1.50 each way. This schedule resulted in average fares of about 33¢ for all crossings during the first months, decreasing to 30.4¢ in 1936.

In 1937 the automobile cash rate was reduced to 25¢ and, with an adjustment in truck rates to classify them by carrying capacity of tire equipment, the average rate fell to a 27¢ to 28¢ range. In 1940 the auto rate was again reduced, to 20¢ cash fare, with commutation rates as low as 15¢, and the average rate has since ranged between 19¢ and 20¢. These variations are shown on the accompanying ratio graph, Fig. 2.

The gross revenue in the first calendar year of operation, 1930, was $399,000, which was not equalled again until 1936, since the bridge was opened within a few weeks after the market crash in the fall of 1929, and the volume of traffic and amount of revenues declined to a minimum in 1933. The slow recovery of business in the middle 1930's and practically complete restoration in 1939 are reflected in the curves of Fig. 2.

In 1941, Louisville became the center of a large defense plant development, particularly in the adjacent Indiana area. Cross-river automobile traffic was trebled in one year's time, and gross revenues were more than doubled. This heavy travel continued, in only slightly decreased volume, during the remainder of the war period, and with the increased net revenues, the Louisville Bridge Commission was able to retire its outstanding bonds at an accelerated rate, saving eight years on the schedule of retirement anticipated in 1940, just before the local boom started.

The operations of the commission in administration of the outstanding bond issue from time to time were of prime importance and considerable interest. Fig. 3 indicates these operations graphically, showing the use made through the construction fund of the proceeds of the original \$5,500,000 of $4\frac{1}{2}$ percent bonds in 1928. Because of a substantial saving in construction costs, from unexpectedly low prices, the resulting surplus of funds was applied to retirement of some bonds immediately upon completion of the bridge in 1929. By 1935, a total of \$1,100,000 of bonds had been retired, of which only \$425,000 had been called using net proceeds from toll collections, far less than had been expected, due largely to the depressed business conditions.

The future looked very promising, however, for one thing because interest rates in the general bond market had dropped materially. The commission received proposals for refunding the remaining outstanding bonds and accepted one offering a $3\frac{3}{4}$-percent interest rate. To pay the call premium of four points on \$4,400,000 outstanding $4\frac{1}{2}$-percent bonds, a total of \$4,435,000 of $3\frac{3}{4}$-percent bonds were sold. The interest savings of $\frac{3}{4}$ percent much more than offset this increase in outstanding bonds, so the commission obtained a very important long range advantage.

In the following year, 1936, bond interest rates were still in a sharp decline and a second refunding through the issue of \$4,400,000 of 3-percent bonds was completed. Retirement of this issue proceeded very satisfactorily to 1940 when a third refunding and another $\frac{3}{4}$-percent interest rate reduction was profitably accomplished through the sale of \$3,670,000 of $2\frac{1}{4}$-percent bonds. A very conservative retirement schedule, as shown in Fig. 3, was prepared for this last operation since more than half of the issue was in revenue bonds maturing on a serial basis of \$200,000 per year for ten years and the remainder, \$1,670,000, in term bonds maturing in 1955.

However, with the boom in revenues following 1940, the entire refunding issue was retired in only six years, freeing the commission of all indebtedness, enabling it to remove all tolls and to turn the bridge over to the Kentucky highway department for future maintenance and operation as a free crossing of the Ohio.

Important role of engineers

The property and operations of the commission have remained under the supervision of the consulting engineers under the terms of the several trust indentures, for the protection of the commission itself and of the holders of the outstanding bonds. It has been a continuing covenant of the commission that, so long as any bonds were outstanding, they would "employ engineers of national repute as to skill and experience in the construction and operation of toll bridges of a size and cost approximating or exceeding the size and cost of its bridge.

Among the duties of the engineers, following design and supervision of construction, have been "to make recommendations as to any necessary or advisable adjustment of the toll schedule, to make an inspection at least once a year of the bridge properties, submitting advices and recommendations as to the proper maintenance, repair and operation of the bridge in the ensuing year along with an estimate of the amount of money necessary therefor (in other words, prepare an annual operating budget), and of the amount that should be set aside for a reserve fund for unusual or extraordinary maintenance."

While the Louisville Bridge Commission pioneered this financing plan, it has not been the first public agency to pay off all outstanding bonds on a revenue project. However, many of the other projects have benefited from special financial aids, such as payment of operation and maintenance charges by the state highway departments or by federal grants.

A listing of only the major projects carried out or refunded and substantially improved under this plan in the last seventeen years would total over a billion dollars and would include the Delaware River Bridge at Philadelphia, the Trans Bay Bridge at San Francisco, the many large bridges and tunnels of the Port of New York Authority, the Mississippi River Bridge at New Orleans, and the 160-mile superhighway of the Pennsylvania Turnpike Commission.

The revenue plan has since been adapted for use in basic financing of local sewerage systems, parkway systems, public buildings for certain purposes, and it is proposed for use on the \$150,000,000 Idlewild Airport for New York City, and for a passenger carrying cableway from the City of Palm Springs, Calif., to the top of adjacent Mount San Jacinto where a winter sports area is planned. Apparently only a beginning has been made in the use of this type of financing in the field of engineering works.

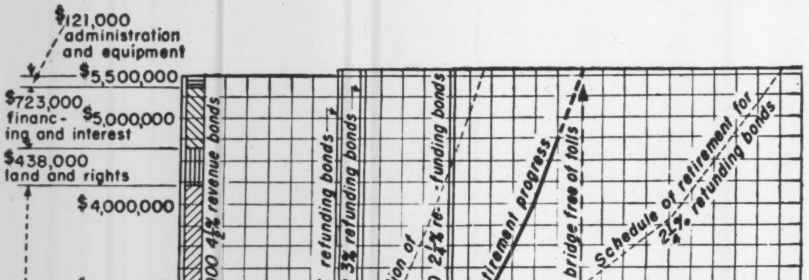

Fig. 3. The graphical history of the administration of the revenue bond issue for the Louisville Bridge from its sale in 1928 to its retirement in 1946.

SPECIAL HIGHWAY SECTION

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A Time For Stock Taking

IT COULD be said that highway construction in 1946 fought a losing battle—much of the labor, materials and funds that should have gone to new construction had to be diverted to corrective maintenance in a desperate effort to prolong the life of many miles of wartime-neglected roads on the verge of complete failure. Then too, the supply of engineers and trained construction personnel was woefully inadequately; equipment was scarce, repair parts almost non-existent; construction materials were in short supply; and fluctuating wage rates coupled with decreased labor efficiency were enough to discourage even the most stout-hearted contractor. But in spite of these obstacles, the dollar volume of new work put under contract rose to levels attained in prewar years, as will be seen by the statistics in the following pages.

Dollar volume in the prewar years, however, no longer can be taken as a measure of the adequacy of a year's highway operations. Unit costs have gone up, hence each dollar buys less completed highway. Moreover, more dollars than ever before are required to take care of increased traffic, deferred maintenance and accumulated obsolesence. As a result, there is great need for stock taking and for a reorientation of highway thinking.

The seriousness of the highway situation as the year 1947 opens was emphasized by Thomas H. MacDonald, Commissioner of Public Roads, at the recent annual meeting of the American Association of State Highway Officials. Despite a great increase in traffic, said Mr. MacDonald, there has been a constantly declining expenditure on the nation's highways as a whole since 1930, which has resulted in a backlog of several billion dollars in deferred construction expenditures needed to replace obsolete main state highways, to provide facilities for relief of traffic congestion in cities and to make needed improvements on the principal secondary roads. "Thus the very existence of the continually depreciating highway plant imposes on highway administrators and engineers the necessity to plan for a continuous rather than a sporadic program of construction and maintenance".

Programing of this kind requires that each state make a resurvey to determine what its maintenance costs are going to be during the period required to catch up on deferred replacement, what new construction must be undertaken annually to put the state's highway system on a sound operating basis, what that work will cost at the higher price levels of today, and whether the state's visible sources of highway income are adequate to meet these greatly increased demands.

Because of the importance of costs to all this planning, a considerable part of this special highway section has been given over to cost trends.

Finally, under the reorganization of Congress, highways have lost their former champions there. Road planning now is grouped with all other types of public work. As a result, state highway officials may find themselves faced with the problem of educating members of Congress on the importance of a continuing program of federal aid to highways rather than a sporadic one. Fortunately, President Truman, in his message to Congress on the national economy, stressed the importance of appraising the size and character of a public-works program on the basis of long-term needs.

Early action looking toward compilation of the data needed to argue the case for a continuing highway program in Congress, therefore, is imperative.

Highway Accomplishments and Plans

***Contents in Brief**—Despite unprecedented shortages of materials, labor, equipment, personnel and in some states of contractors, the state Highway departments in 1946 put 254 percent more new construction under contract than in 1945. They are budgeting an increase of 58 percent in new construction in 1947 over the 1946 volume. Some states are carrying an unusually large volume of uncompleted construction over into 1947.*

STATE HIGHWAY construction is heading for a billion dollar year in 1947 with another third of a billion budgeted for maintenance. These record totals come out of reports to *Engineering News-Record* from 48 states and the District of Columbia and represent 58 percent increase over the 1946 construction programs, a 14 percent increase in maintenance or an overall 54 percent increase in all state highway work.

Construction and maintenance in 1946 reported by 45 states and the District of Columbia totals $959,896,000 and these same states hope to increase this to $1,476,176,000 in 1947.

Construction alone, reported by 44 states and the federal district totals $642,969,000 for 1946, a 254 percent increase over 1945. The 1947 program of $1,017,709,000 for these same units, is a 58 percent increase over 1946.

Maintenance ran high

Maintenance alone, reported by the district and 46 states, amounts to $291,624,000 for 1946, with $335,417,000 their 1947 goal.

The largest gains in construction are budgeted in Middle Atlantic states, 60 percent; New England, 99 percent; South, 64 percent, with Far West at 51 percent and West of Mississippi at 53 percent and Middle West at 51 percent, in the lower bracket.

The largest increases in maintenance are budgeted in Far West, 35 percent; Middle Atlantic, 23 percent; Middle West, 18 percent. West of Mississippi at 15 percent, South at 8 and New England at 6 percent are in this lower bracket.

These increases have been attained in spite of the worst shortages that the industry has had to cope with. Labor shortages are reported in Michigan, California, Wyoming, Missouri, Illinois, Vermont, South Dakota; material shortages in Michigan, Delaware, Louisiana, North Carolina, Mississippi, California, Missouri, Illinois, Vermont, Washington, Iowa, South Dakota and New York. Steel is short in Wisconsin, Nebraska, Minnesota, Wyoming, Illinois, Washington, Massachusetts and Utah; cement in Illinois; aggregates in Illinois; lumber in Vermont and Massachusetts.

Right-of-way troubles are found in Minnesota and in California where the housing shortage prevents dwelling removals to clear right-of-way for the expressway program. Car shortages plague Illinois.

Lack of contractors is reported by Mississippi, Minnesota (especially for grading), South Carolina (bridges) and Delaware. Lack of engineers is handicapping North Carolina, Nebraska, Mississippi, Delaware, Utah and Louisiana.

Large carry-overs

In spite of these conditions, 14 states report that they are not carrying an unusual volume of uncompleted work in 1947, while 10 are carrying over an abnormally large volume. They are Massachusetts, Virginia, Georgia, Iowa, Montana, Wyoming, Arizona, Washington, and the District of Columbia. The following states report their carry-over to be: New York, $54,858,000 including some incomplete work awarded in the latter part of 1945; New Jersey, 17.355 miles of highway and 21 bridges; Maryland, $7,200,000; North Carolina, $6,647,000; Florida, $9.500,000; Alabama, $6,520,000 or 59 percent of work contracted; Mississippi, $6,918,000; Louisiana, $5.772,000; Kentucky, $5,000,000; Tennessee $7,125,000; Illinois, $8,812,000; Wisconsin, $4.500,000; Michigan, $15,000,000; Minnesota, $5,500,000, mostly grading contracts; South Dakota, $2,812,000; Nebraska, $1,681,000, 20% of 1946 contracts; Kansas, $15,111,000 compared with $4,000,000 carried into 1946 from 1945; Oklahoma, $18.554,000; Texas, $22,000,000 due to bad weather in last 4 months and shortages; Oregon, $9,000,000 and California, $38,000,000.

New work approaches 30,000 miles

The mileage improved in 1946 totals 28,585 miles reported by 45 states and the District of Columbia, with Pennsylvania, Texas and Wyoming missing. This includes 2,721 miles of hard surface, 16,876 miles of bituminous types, 2,497 miles of aggregate or soil surface, and 5,019 miles of graded and drained in 43 states and the district, a total classified by types of 27,113 miles, of which 10 percent was hard surface, 62 percent bituminous types, 9 percent aggregate or soil surface, and 19 percent graded and drained.

Above this national average in hard-surface highway mileage are the New England states with 32 percent, Middle Atlantic states with 53 percent and Middle West with 15 percent. West of Mississippi states, with 10 percent, agree with the national average and the Southern states with 6.5 percent and Far West with 5 percent are below the average for hard surface construction.

For bituminous types, the national average of 62.5 percent is exceeded in the South with 76 percent, in the Middle West with 76.5 percent and in Far West with 69.5 percent.

Aggregate and soil surfacing was constructed in the South, 4 percent of the total new mileage, in the Middle West, 3 percent, West of Mississippi, 17.5 percent, Far West, 11 percent.

Graded and drained mileage represented 31 percent of the total in the states west of the Mississippi, 21 percent in the Middle Atlantic, 15 percent in the Far West, 13 percent in New England, 13 percent in the Southern states and 6 percent in the Middle West.

STATE HIGHWAY PROGRAMS—1946-1947

Reported to Engineering News-Record by Highway Officials

	EXPENDITURES — 12 MONTHS Thousands of dollars (,000 omitted)									1946 — MILEAGE BY TYPE					Equipment Purchases	
	New Construction			Maintenance and Equipment			Total			Hard Surface	Bituminous	Aggregate Soil	Graded, Drained	Bridges	Thousands of dollar (,000 omitted)	
	1946	1947 (Est.)	% Increase	1946	1947 (Est.)	% Increase	1946	1947 (Est.)	% Increase	Miles	Miles	Miles	Miles	Miles (Structures)	1946	1947 (Est.)
Maine	$2,120	$2,460	+16	$6,872	$6,000	−13	$8,992	$8,460	−6	23.3	40.9	.....	.....	0.34	$372	$150
New Hampshire	1,976	4,568	131	3,140	3,416	9	5,116	7,984	56	.....	26.5	.....	.....	0.50	140	216
Vermont	2,694	2,940	9	1,998	1,948	−3	4,692	4,888	4	38.1	22.0[8]	.....	14.7	0.20	158	108
Massachusetts	9,500	12,400	31	4,928	5,850	19	14,428	18,250	26	14.9	28.6	.....	2.5	1.10	520	700
Rhode Island	150	......	u	1,750	2,200	26	1,900	......	u	.....	16.0	.....	.....	....	150	200
Connecticut	5,048	20,000	296	4,544	5,210	15	9,592	25,210	163	7.8	11.0	.....	15.8	0.33	292	910
New England	**21,338** (5)	**42,368**	**99**	**23,232** (6)	**24,624**	6	**42,820** (5)	**64,792**	**51**	**84.1**	**145.0**	.....	**33.0**	....	**1,632** (6)	**2,284**
New York	**99,178**[2]	156,265	58	17,350	23,000	33	116,528[2]	179,265	54	163.0	66.0	.....	83.0	....	350	2,000
New Jersey	13,722	30,000	119	5,774	6,500	13	19,496	36,500	87	9.7	.....	.....	10.4	(22)	.....	.....
Pennsylvania	......	......	u	......	.....	u	35,000	137,000	291	.....	.....	.....	.....	....	1,250	2,000
Maryland	12,000	12,500	4	3,740	3,500	−6	15,740	16,000	2	26.0	40.0	.....	.....	1.00[4]	240	.....
Dist. Columbia	3,882	6,680	72	568	663	17	4,450	7,343	65	15.0	20.0	.....	8.0	1.00	45	63
Delaware	1,750	3,430	96	1,325	1,750	32	3,075	5,180	68	39.0	.....	.....	.....	....	125	250
Mid. Atlantic	**130,532** (5)	**208,875**	**60**	**28,757** (5)	**35,413**	**23**	**194,289** (6)	**381,288**	**96**	**252.7**	**126.0**	.....	**101.4**	....	**1,770** (4)	**4,313**
Virginia	10,302	40,000	288	30,857	28,000	−9	41,159	68,000	65	42.3	140.1	.....	2.4	1.36	3,260	2,000
West Virginia	5,940	17,000	186	12,204	12,000	−2	18,144	29,000	60	1.4	9.0	35.9	69.0	(8)	975	2,000
No. Carolina	21,568	20,500	−5	21,535	23,000	7	43,103	43,500	1	36.5	1,634.0	.....	120.5	2.05	3,035	4,000
So. Carolina	15,200	20,000	32	5,175	7,000	35	20,375	27,000	33	.....	720.5	.....	0.3	3.40	175	1,000
Georgia	32,000	32,000	0	6,272	6,000	−4	38,272	38,000	−1	<—1,258.6—>		.....	99.5	3.96	1,272	1,000
Florida	22,500	25,000	11	3,500	5,000	43	26,000	30,000	15	.....	1,400.0	.....	150.0	2.88	.....	.....
Alabama	11,200	18,000	61	3,950	3,680	−7	15,150	21,680	43	307.0	280.0	.....	236.0	0.87	580	.....
Mississippi	4,000	15,000	275	4,000	4,000	0	8,000	19,000	138	40.6	106.2	.....	214.8	0.79[5]	1,000	500
Louisiana	2,893	19,074	559	9,671	16,439	70	12,564[3]	35,513[3]	183	30.9	183.1	72.2	3.2	1.69	651	2,000
Kentucky	10,022	18,000	80	5,964	6,000	1	15,986	24,000	50	94.7	1,668.9	.....	216.4	8.25	1,000	1,000
Tennessee	11,600	17,535	51	4,770	5,830	22	16,370	23,365	43	23.0	533.0	225.0[11]	80.0	(12)	773	500
Southern	**147,225** (11)	**242,109**	**64**	**107,898** (11)	**116,949**	**8**	**255,123** (11)	**359,058**	**40**	**576.4**	**6,674.8**	**333.1**	**1,192.1**	....	**12,141**	**14,000**
										<—1,258.6—>						
Ohio	18,515	30,000	62	8,960	8,000	−11	27,475	38,000	38	49.6	2,320.0	117.0	5.0	(64)	.....	.....
Indiana	17,046	29,125	71	4,575	7,756	70	21,621	36,881	71	104.2	430.1	.....	9.5	(63)	**444**	700
Illinois	12,399	......	u	7,947	11,750	48	20,345	......	u	83.1	384.0	23.1	.....	(48)	.....	.....
Wisconsin	**14,644**[2]	25,000	71	8,000	9,000	13	22,644[2]	34,000	50	327.2	312.1	.....	147.3	(38)	.....	.....
Michigan	**22,000**[2]	25,000	14	10,500	10,500	0	32,500[2]	35,500	8	135.0	106.0	.....	97.0	(40)	.....	.....
Middle West	**72,205** (4)	**109,125**	**51**	**39,982** (5)	**47,006**	**18**	**104,240** (4)	**144,381**	**38**	**699.1**	**3,552.2**	**140.1**	**258.8**	....	**444** (1)	**700**
Minnesota	18,600	20,000	8	9,000	9,500	6	27,600	29,500	7	90.0	337.0	.....	617.0	0.05[6]	.....	.....
Iowa	13,381	20,000	49	5,300	6,050	14	18,681	26,050	39	74.8	85.2	.....	603.5	....	300	450
Missouri	10,684	56,200[1]	426	8,425	9,250	10	19,109	65,450[1]	243	310.3	725.2	.....	.....	1.00	425	750
Arkansas	8,503	......	u	......	......	u	......	......	u	.....	120.5	123.6	41.1	0.43	.....	.....
No. Dakota	2,750	6,500	136	514	1,475	187	3,264	7,975	144	.....	29.4	.....	136.2	....	284	675
So. Dakota	2,510	10,204	307	3,250	3,250	0	5,760	13,454	134	14.8	139.0	.....	237.0	(12)	350	400
Nebraska	8,405	12,000	43	4,480	4,320	−4	12,885	16,320	27	49.0	414.0	.....	330.0	(49)	680	320
Kansas	**24,430**[2]	28,705	17	7,119	8,910	25	**31,549**[2]	37,615	19	144.8	938.9	877.3	470.8	(115)	2,199	2,160
Oklahoma	**26,973**[2]	19,873	−26	4,182	4,200	0.4	31,155	24,073	−23	152.2	271.6	626.0	223.9	(128)	.....	.....
Texas	**54,400**	65,500	20	11,893	16,000	35	66,293	81,500	23	u	u	u	u	u	950	1,500
Montana	6,200	13,000	110	3,300	3,300	0	9,500	16,300	72	95.6	138.7	.....	31.2	0.17	300	300
Wyoming	7,500	8,000	7	1,700	2,000	18	9,200	10,000	9	.....	.....	.....	.....	....	450	450
Colorado	6,000	22,000	267	2,550	2,400	−6	8,550	24,400	185	.....	28.7	.....	132.0	0.40[7]	250	400
New Mexico	10,050	12,500	24	1,502	2,250	50	11,552	14,750	28	.....	629.0	.....	87.7	0058	500	250
West of Miss.	**191,883** (13)	**294,482**	**53**	**63,215** (13)	**72,905**	**15**	**255,098** (13)	**367,387**	**44**	**931.5**	**3,857.2**	**1,626.9**	**2,913.4**	....	**6 588** (11)	**7 655**
Idaho	5 990	6,450	8	3,020	3,620	20	9,010	10,070	12	5.0	665.0	.....	105.0	0.11	560	450
Utah	**4,250**	6,100	**44**	2,320	2,900	31	6,570	9,000	37	5.8	99.0	.....	13.0	0.30	220	400
Arizona	7,500	9,000	20	1,500	2,000	33	9,000	11,000	22	13.0	164.0	.....	22.0	0.5	140	500
Nevada	5,515	5,200	−6	1,150	1,350	17	6,665	6,550	−2	.....	168.0	92.0	.....	....	250	300
Washington	10,031	19,000	89	900	6,500	622	10,931	25,500	133	31.2	554.6	<—214.1—>		0.93	400	1,000
Oregon	**14,500**[2]	15,000	4	6,450	8,400	30	20,950	23,400	12	7.0	390.0	305.0	380.0	0.54	450	1,200
California	32,000[9]	60,000	88	13,200	13,750	**4**	45,200	73,750	63	115.0	480.0	.....	.....	(110)	1,200	1,750
Far West	**79,786** (7)	**120,750**	**50**	**28,540** (7)	**38,520**	**35**	**108,326** (7)	**159,270**	**46**	**177.0**	**2,520.6**	**397.0**	**520.0**	....	**3,220** (7)	**5,600**
												<—214.1—>				
U.S.	**$642,969** (45)	**$1,017,709**	**58**	**$291.624** (47)	**$335,417**	**14**	**$959,896** (46)	**$1,476,176**	**54**	**2,720.8**	**16,875.8**	**2,497.6**	**5.018.7**		**$25,795** (38)	**$34,552**
										<—1,258.6—>		**<—214.1—>**				
										<——28,585.6 (46)——>						

( ) Numbers in ( ) show number of states represented in figure reported.

u — Unavailable. [1] Money available, probably will not be able to contract entire amount. [2] Includes carryover 1946 to '47, N. Y. $54,858; Wis., $4,500; Mich. $15,000 (1947 est. assumes same carryover into 1948); Kans. $15,110 (less $4,000 from '45 to '43); Okla. $18,554; Ore. $9,000 (less $2,400 from '45 to '46). [3] Plus State aid to Parishes, '46, $666[0] '47, $867.

[4] 11 structures. [5] 49 structures. [6] 7 structures. [7] 27 structures. [8] Plus 13.8 miles bituminous shoulders. [9] Calif. $38 000 carryover not incl.

(Minor corrections of data originally supplied, that do not change these overall conclusions, have come in too late to be incorporated in this table. They will be available, on request, in reprint form.)

This table of highway statistics is based on information supplied to *Engineering News-Record* by the following highway officials: Maine, Lucius D. Barrows and R. M. Page; New Hampshire, D. H. Dickinson; Vermont, H. E. Sargent, A. W. Coleman; Massachusetts, P. H. Kitfield; Rhode Island, G. H. Henderson; Connecticut, W. J. Cox, W. C. Murray.

New York, T. F. Farrell, R. J. Shillinglaw; New Jersey, C. M. Noble; Pennsylvania, T. C. Frame; Maryland, W. T. Ballard; District of Columbia, H. C. Whitehurst, J. N. Robertson; Delaware, W. A. McWilliams.

Virginia, C. S. Mullen; West Virginia, E. L. Worthington, M. L. O'Neale; North Carolina, W. V. Baise; South Carolina, C. R. McMillan; Georgia, G. T. McDonald, T. D. House; Florida, H. P. Coloney; Alabama, E. N. Rodgers; Mississippi, R. A. Harris, J. D. Monnette; Louisiana, N. E. Lant, J. A. Kinkaid; Kentucky, T. H. Cutler; Tennessee, W. T. Brooks and L. N. Means.

Ohio, M. D. Shaffer; Indiana, C. E. Vogelgesang; Illinois, W. W. Polk; Wisconsin, E. L. Roettiger; Michigan, C. M. Ziegler.

Minnesota, O. L. Kipp; Iowa, F. R. White; Missouri, C. E. Brown, G. M. Threlkeld; Arkansas, W. W. Zass; North Dakota, M. P. Wynkoop; South Dakota, E. W. Meeker; Nebraska, F. H. Klietsch; Kansas, R. C. Keeling; Oklahoma, H. E. Bailey; Texas, D. C. Greer; Montana, H. W. Holmes; Wyoming, J. R. Bromley, C. W. Beaver; Colorado, M. V. Watrous; New Mexico, B. G. Dwyre.

Idaho, J. O. Reid; Utah, R. W. McLeese; Arizona, W. C. Lefebvre; Nevada, R. A. Allen; Washington, C. B. Shain, E. C. Simpson; Oregon, R. H. Baldock, S. H. Probert; California, G. T. McCoy, F. Grumm.

New Jersey Starts "Dual-Dual" Highway To End Serious Traffic Congestion

Charles M. Noble
State Highway Engineer
New Jersey State Highway Department, Trenton, N. J.

***Contents in Brief**—A traffic problem of unprecedented magnitude has been created in metropolitan northern New Jersey by the movement of motor vehicles to and from the port of New York and New England being superimposed on the very large amount of traffic originating in that region. As topographic and other physical limitations make dispersion of highways approaching New York impracticable, the New Jersey Highway Department has begun construction of a new highway on which there ultimately will be four separated two-lane roadways each of which will have a paved parallel shoulder for use in emergencies.*

New Jersey has begun its attack on a traffic problem that is without parallel anywhere in the country. Late in 1946, contracts were let for the first sections of a highway whose physical characteristics were largely dictated by the fact that topographic limitations make it necessary to concentrate within a single right-of-way an amount of traffic that could better be handled on two or three modern divided highways. This freeway, legislated as Route 100, has been designated in New Jersey a "dual-dual" highway. It will consist of a total width of eight lanes which will be divided into four roadways of two lanes each. The two northbound roadways will be separated from the southbound, and the through traffic roadways will be separated from those carrying shorter haul traffic.

Population and industry concentrated

Of the 48 states, New Jersey ranks 45th in size, ninth in population and second to Rhode Island in density of population. It ranks sixth as an industrial state, and 80 percent of its population is urban.

New Jersey lies in the center of a cluster of states that contain 24 percent of the population and 35 percent of the industry of the entire United States. The state lies between New York, with the largest population, and Pennsylvania, with the second largest population in America. A comparison with these states is interesting. For example, New Jersey contains less than 17 percent of the area of New York, yet it has nearly 45 percent of the motor vehicle registration of that state. Compared with Pennsylvania, New Jersey has an area a little more than 17 percent as large, but has a motor vehicle registration equal to 52 percent of the Keystone State.

Furthermore, New Jersey lies directly between New York City and Philadelphia, the first and third largest cities in the United States, with combined metropolitan area populations in excess of 14,000,000 people, roughly 10 percent of the population of the nation. All highway traffic between these cities as well as highway traffic to New York City from the south and west, and all traffic from eastern New York and New England to Philadelphia passes through New Jersey.

If the heavy concentration of population, motor vehicle registration and industry was spread over the entire 8,200-sq. mi. area of the state, the highway transportation problem would be difficult enough, but in a state where 40 percent of the entire area is given over to agriculture and another 40 percent is occupied by woodlands, population, vehicle registration and industry are concentrated in a comparatively small area. The Northern New Jersey area forms a part of the great metropolitan section of New York City. In the six counties of Essex, Hudson, Union, Bergen, Passaic and Middlesex live 2,800,000 people. In those same counties are located 69½ percent of all state industry and 55 percent of all motor vehicle registration.

Pioneered in highway development

At an early date in the motor transportation era the state was subjected to problems associated with heavy volumes of fast moving truck and passenger car traffic, and as a result the engineers in the New Jersey State Highway Department became pioneers and leaders in modern highway design and construction techniques and policies. The period starting in the early 1920's and terminating in the depression years witnessed such bold and outstanding developments as the approaches of the Camden Bridge through the metropolitan Camden area, the great Pulaski Skyway with its high-level crossings of the Passaic and Hackensack rivers and the grade-separated approaches to the Holland Tunnel through the heavily congested and built up area of Jersey City, the grade-separated approaches to the George Washington Bridge, the construction of U. S. 1 from the Hudson River to Trenton thus inaugurating one of the major highways in the world, and the construction of a substantial portion of the total dual highway mileage in America.

Thus New Jersey anticipated and led in the solution of many problems that have only recently begun to be experienced in many sections of the country, and at all times the state has been constantly and unremittingly subjected to the pressure of a vast and continually increasing volume of traffic.

New Jersey came face to face with the traffic problem 20 years ago, and the development of the highway transportation system in this state has been influenced by the necessity of providing facilities for large masses of passenger cars and trucks rather than by the urge of getting traffic out of the mud, as was the case in many of the less developed areas in America.

Traffic congestion builds up

Although highway construction in New Jersey has been greatly curtailed since 1936, vehicle registration and use continued to grow until Pearl Harbor clamped restrictions on fuel. Therefore, today there is a ten-year backlog of urgently needed modern highway improvements, amounting to more than $200,000,000. Thus, congestion and its strangling effect on commerce and industry threaten the state acutely.

During the war, State Highway Commissioner Spencer Miller, Jr., foresaw the peacetime traffic needs in the years ahead and realized that those needs could only be met by planning and executing a bold program involving the construction of a system of freeways and parkways. With the sponsorship of Governor Edge he vigorously laid these proposals before the people of New Jersey with such effect that a freeway and parkway law was enacted by the legislature in 1945.

Under this law, freeways and parkways are defined as follows: "Freeway shall mean a state highway especially designed for through mixed traffic over which abutters have no easement, or right, of light, air or direct access, by reason of the fact that their property abuts upon such a way, with infrequent public entrances and exits and with or without service roads."

"Parkway shall mean a state highway especially designed for passenger traffic over which abutters have no easement, or right, of air, light or direct access, by reason of the fact that their property abuts upon such a way, with special treatment in landscaping and planting between roadways and along its borders, which borders may include service roads open to mixed traffic, recreational facilities such as pedestrian, bicycle and bridle paths, overlooks and picnic areas, and other necessary non-commercial facilities."

Plans for Route 100

Under this law, Route 100, which originally had been added to the state highway system in March, 1938, to provide relief for the badly congested Route 25 (U. S. Route 1) as it approached New York, became a freeway. As legislated, this limited-access highway, capable of carrying an immense volume of mixed traffic with free flow, will extend from the George Washington Bridge to a connection with Route 26 south of New Brunswick (See Fig. 1 and 3) passing in the vicinity of Ridgefield, North Bergen, Newark, Elizabeth and Woodbridge; with a branch extending from the northern limits of Elizabeth across Newark Bay to Bayonne. South of the Passaic River the route will be to the east of Route 25 (U. S. Route 1).

The construction of the legislated portion of Route 100 will be divided into four main programs, which in turn may be sub-divided into two or more steps each. Priority for these programs is being established with the intention of giving the greatest relief to existing "bottlenecks" in the order of their importance.

The 1st Program will extend from a connection on Route 25 in the vicinity of Bonhamtown (north of the Raritan River), northerly through Middlesex and Union counties to a connection back to Route 25 at the

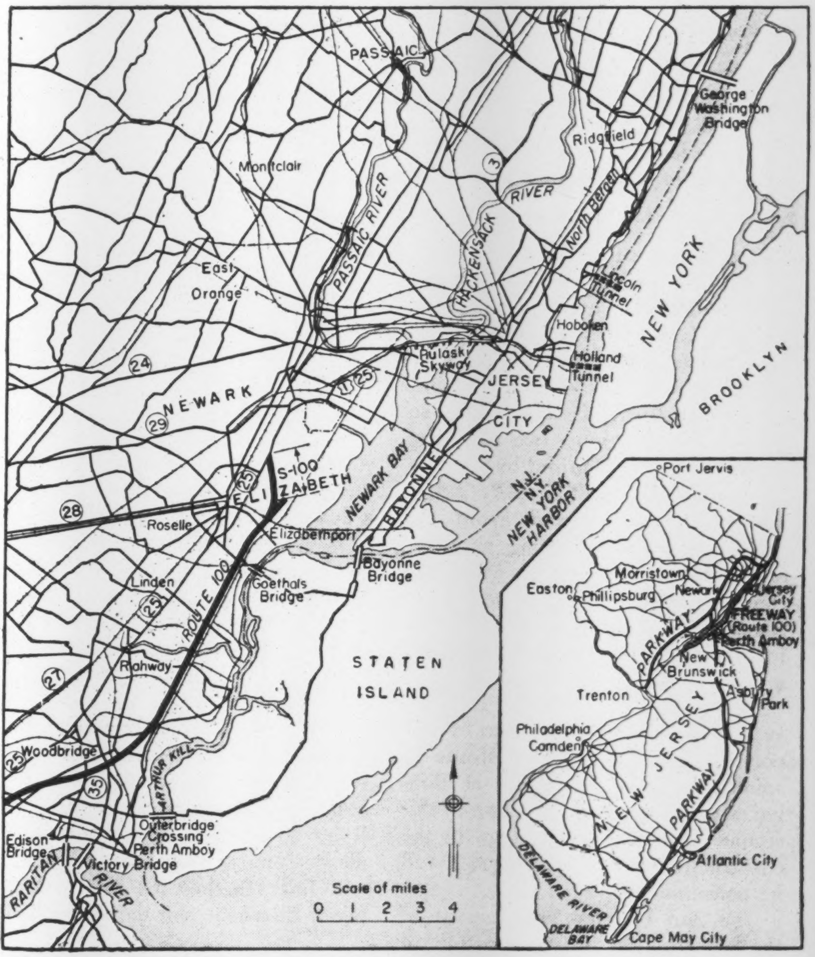

PASSAIC
George Washington Bridge
Ridgefield
Montclair
PASSAIC RIVER
3
HACKENSACK RIVER
North Bergen
Lincoln Tunnel
NEW YORK
East Orange
Hoboken
Holland Tunnel
BROOKLYN
Pulaski Skyway
24
NEWARK
29
1
25
JERSEY CITY
S-100
ELIZABETH
NEWARK BAY
BAYONNE
N.J.
N.Y.
NEW YORK HARBOR
28
Roselle
Elizabethport
Bayonne Bridge
Linden
Goethals Bridge
25
ROUTE 100
STATEN ISLAND
Rahway
27
25
Woodbridge
35
ARTHUR KILL
Outerbridge Crossing
Perth Amboy
Edison Bridge
Victory Bridge
RARITAN RIVER
Scale of miles
0 1 2 3 4
Port Jervis
Morristown
Easton
Phillipsburg
Newark
Jersey City
FREEWAY (Route 100)
Perth Amboy
PARKWAY
New Brunswick
Trenton
Asbury Park
Philadelphia
Camden
NEW JERSEY
PARKWAY
Atlantic City
DELAWARE RIVER
DELAWARE BAY
Cape May City

Fig. 1. In the part of New Jersey lying to the west of the Hudson River at New York, highways approaching New York from the south and west must pass to the north of Newark Bay through an area largely occupied by the cities of Newark and Elizabeth as well as numerous main line railways, oil refineries and Newark Airport. On the insert map of New Jersey are shown the locations of the projected freeway through this area, Route 100, and also the projected parkways.

northern limits of the City of Elizabeth, a distance of 16.1 miles. This program will provide a relief valve for Route 25 and will serve the immense population in the metropolitan area of Northern New Jersey as well as a tremendous concentration of industry, business and commerce.

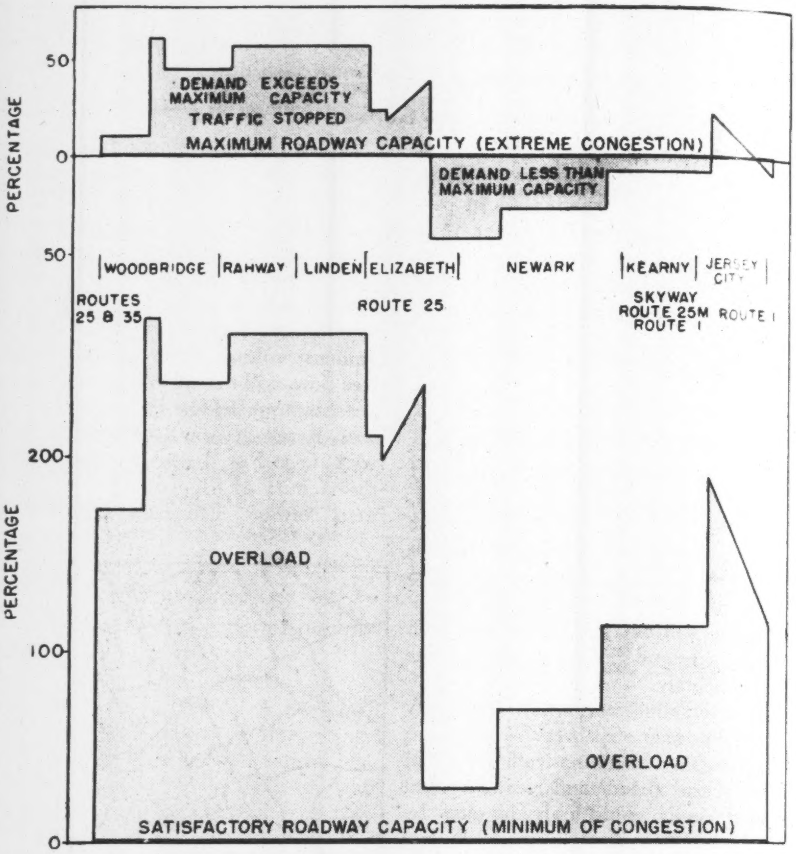


Fig. 2. A study of traffic congestion on Route 25 showed that the greatest overload was on the section north of the junction of Routes 25 and 35 through Woodbridge, Rahway, Linden and Elizabeth.

The first step in this 1st Program will consist of completing as rapidly as funds permit the 11-mile section between Route 35 and Route 25 at Elizabeth. It would not be feasible to complete shorter sections, which would be usable by any significant traffic volumes, due to the topography and development of the present highway system in this territory.

This portion of the highway will then provide an alternate route from Elizabeth south, for the great flow of traffic to and from New Jersey's seashore resorts. At the northern end of Step 1, Route S-100 will make a connection with Route 25 at Elizabeth, and when Route 100 is eventually extended beyond this point this spur will serve as an interchange.

Outer roadways built first

Traffic studies indicate that the provision of the full eight-lane traffic capacity is desirable but not necessary initially, and construction will proceed on the basis of providing the two outer roadways, or four lanes, at the outset and the facility will be so designed that the inner two roadways can be added as required by increasing traffic. This will simplify initial interchange design and avoid the necessity of reconstructing acceleration and deceleration lanes and interchange ramps when the additional roadways are constructed. Grading for full eight-lane width will be done initially.

The second step of the 1st Program will be the construction of that portion of Route 100 from Route 35 southwesterly to Route 25 at Bonhamtown. With the completion of this second step, the initial stage in the construction of the 1st Program will be consummated.

The 2nd Program will consist of the construction of that portion of Route 100, generally referred to as the "Trans-Meadow" section, extending from the Pulaski Skyway to the George Washington Bridge. Coupled with the present re-construction of Route 25 from Elizabeth to the Skyway, with which this second-step construction will connect, work done under the 2nd Program will provide a dual-dual highway from the bridge to Route 25 at Bonhamtown north of the Raritan River.

Reconstruction of Route 25 between Elizabeth and the Pulaski Skyway is a major operation in itself as that highway is elevated to carry it over railroad yards.

The 3rd Program will extend Route 100 from Bonhamtown southward, across the Raritan River over a new bridge to a connection with Route 26 near Adams Station in Middlesex County, while the 4th Program will link together the final gap between Elizabeth and the skyway.

Arrangement of the roadways

Route 100 is best described as a dual-dual highway consisting of four 24-ft. roadways, two in each direction. The outer pair of roadways will handle the slower-speed and shorter-haul traffic, while the inner roads will serve high-speed, through traffic. Each of these roadways is made up of 12-ft. traffic lanes. Through more open country each of these two-lane roads will be flanked by a 5-ft. shoulder on the left or inside, and a 10-ft. shoulder on the outside. Between the two northbound roadways, as well as between the southbound roadways, are 10-ft. grass islands in addition to the shoulders.

Dividing the high-speed north and southbound roadways is a 30-ft. grass island, landscaped with shrubbery, so planted as to exclude headlight glare from on-coming vehicles. All drainage, except for the outer half of the low speed roads will be to the islands, which are depressed at their center. This feature will do much to prevent pavement icing due to intermittent thaws and freezing after snow has been pushed from the roadways to the islands. The adequate island widths will also allow space upon which to deposit snow removed from the highway.

Where Route 100 passes through congested urban areas the right-of-way width will be reduced from 300 ft. down to the minimum required for roadways and slopes. The graded width will be reduced from 226 ft. at roadway level to 174 ft. This narrowing will be affected by (1) reducing the center island from 30 ft. to 12 ft.; (2) reducing the shoulder widths adjacent to the center island from 5 ft. to 3 ft.; (3) replacing the 10-ft. grass-island between the high speed and low speed roadways with a 2-ft. concrete curb; (4) reducing the 5-ft. shoulder on the inside of the low speed roads to 3 ft.; (5) by the use of retaining walls to reduce slope widths.

The outer roadways will be connected with traffic interchange facilities at reasonably frequent intervals while the inner roadways will be provided with interchange facilities at greater intervals.

Minimum radii of 3,000 ft. will be used except in heavily built up areas where 1,600 ft. minimum radii may be permitted. However, minimum values will be permitted only in case of absolute necessity. Generally, radii of curves will range between 6,000 and 20,000 ft. Curves will be super-elevated, and wherever radii of 3,500 ft. or sharper are used, curves will be equipped with transition spirals. Adequate distances between reversed curves and those in the same direction will be maintained.

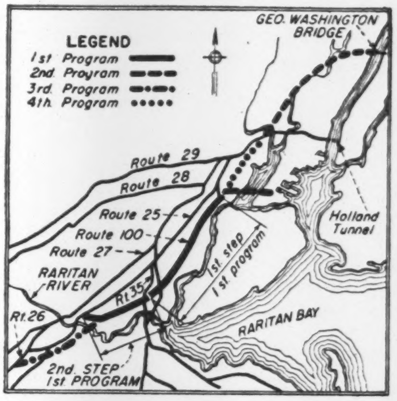

GEO. WASHINGTON BRIDGE
LEGEND
1st Program
2nd Program
3rd Program
4th Program
Route 29
Route 28
Route 25
Route 100
Route 27
RARITAN RIVER
Rt.35
Rt.26
Holland Tunnel
1st step 1st program
RARITAN BAY
2nd STEP 1st PROGRAM

Fig. 3. Work on Route 100 has been divided into four main programs designed to get the maximum of traffic relief at the earliest possible date.

Grades on Route 100 will be held to a maximum of 3 percent, a desirable maximum of 2 percent and a minimum of 0.5 percent. Minimum rear-end-collision sight distances from height of eye to a 4-in. object will be 600 ft., and the car to car vision thus will be nearly 1,200 ft.

Deceleration lanes, initially, will be constructed 800 ft. in length. However, bridge clearances, etc., will be so arranged that these lanes can be extended to a total length of 1,200 ft. Acceleration lanes will be 1,200 ft. long, using a "converging" design. Side slopes of 1 on 4 and flatter will be used on fills up to 10 ft. high in all but the heavily congested urban areas for the dual purpose of eliminating guard rail and to stabilize the slopes against erosion. Gentle slopes will also materially facilitate mowing operations.

Much construction across swamps

Many sections of Route 100, as previously noted, pass through highly developed industrialized urban areas. Because of this, it is the desire of the New Jersey State Highway Department to destroy a minimum of tax ratables and housing units. There-

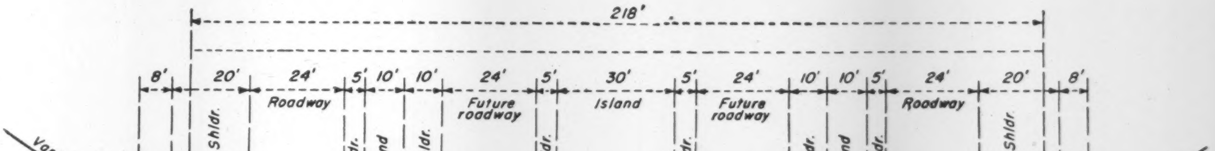

218'
8'
20'
24'
5'
10'
10'
24'
5'
30'
5'
24'
10'
10'
5'
24'
20'
8'
Roadway
Future roadway
Island
Future roadway
Roadway
Shldr.
Island
16'
Variable
Guard fence
TYPICAL SECTION IN OPEN COUNTRY
198'
6'
10'
24'
5'
5'
10'
24'
5'
20'
5'
24'
10'
5'
5'
24'
10'
6'
Curb
TYPICAL SECTION THROUGH OIL REFINERIES
170'
3'
82'
82'
3'
Variable
10'
24'
3'
2'
10'
24'
3'
12'
3'
24'
10'
2'
3'
24'
10'
Wall
℄ C.R.R.
TYPICAL SECTION THROUGH ELIZABETH

Fig. 4. Typical cross-sections of Route 100. Through the city of Elizabeth and past some of the oil refineries it was found necessary to reduce the graded width below limits considered desirable for more open country.

fore, much of the location chosen for the alignment will be across swamps and unsuitable ground, which has retarded development. Construction plans call for the removal of muck in these swampy areas down to a solid bottom (hard pan) and refilling with suitable material to assure solid embankment, subject to minimum settlement. A large number of auger borings have been taken to establish the depth of muck and Meredith Johnson, the state geologist, is advising on all geological matters. Modern soil techniques are being employed. Where natural soils are encountered having a California Bearing Ratio of 10 percent or less, a blanket of selected material 15 in. thick having a maximum of 35 percent of material passing the No. 200 mesh sieve will be utilized. Excavation in cuts will be made to the greater depth to permit the placing of the selected material.

Granular sub-base material 12 in. thick to support the pavement will be placed on top of the selected material. The sub-base material will not contain more than 5 percent of elutriable material.

All fills, selected material, and subbases will be placed in layers of 6-in. thickness, loose measurement, and compacted by heavy rollers, required to make a minimum number of passes per layer of compacted material.

Present plans contemplate reinforced concrete pavement 10 in. thick divided into 12-ft. lanes by tongue and groove longitudinal joints. Expansion joints will be dowelled with 1¼-in. smooth round steel dowels placed 12 in. center to center. A positive and rigid assembly for holding the dowels in correct alignment will be required and positive provision will be made to protect the steel dowels against corrosion.

Paved shoulders flush with the pavement edges, capable of supporting truck loads, of the widths shown in Fig. 4 will be provided. Research is now being conducted for the purpose of developing a very coarse aggregate shoulder pavement which will permit vehicles to turn off the pavement with confidence at high speed, but which will have such a texture and character as will discourage the use of the shoulder as another traffic lane.

This year's work will be confined to areas where there will be a minimum of disturbance to housing units. In all right-of-way negotiations, where it is necessary to disturb housing, the owner is being given the opportunity to retain and relocate his building on vacant land outside the limits of the right-of-way. A high percentage of owners have already availed themselves of this opportunity and consequently relatively few housing units have been destroyed.

As an additional precaution against hardship to property owners, construction in thickly built up areas is being deferred to the last possible moment compatible with completing the first program on schedule. Work at this time is being confined to grading and the construction of minor structures, avoiding, where possible, work requiring materials during the present period of critical shortages and high prices.

The various elements required to complete the first program have been carefully scheduled in suitable contracts so that surveys, plans and actual construction may be executed with smoothness and efficiency.

High costs and large savings

When it is considered that the completion of the 1st Program of Route 100 (16.1 miles) at an estimated cost of $44,000,000 will result in an estimated saving to traffic of $3,150,000 annually in the avoidance of congestion, delay and through the reduction of accidents, there can be no doubt regarding the economic justification of this highway. However, the necessity for a north-south highway of this type goes much farther. At the present time the total north-south average daily traffic in northern metropolitan New Jersey, between Newark Bay and the Orange Mountains, excluding purely local traffic, but including that moving on municipal streets, township and county roads, amounts to approximately 160,000 vehicles a day, of which 85,000 now travel on state highways. If adequate state-highway routes were available now in this territory, it is estimated that 140,000 vehicles a day would travel over them. The present satisfactory capacity of north-south state highways in this area amounts to only 45,000 vehicles a day; thus there is a deficiency at present in state-highway capacity of 95,000 vehicles per day. Congestion of this type is far reaching in its detrimental effect upon the economic life of the state and community.

Route 100 is New Jersey's answer to this traffic problem.

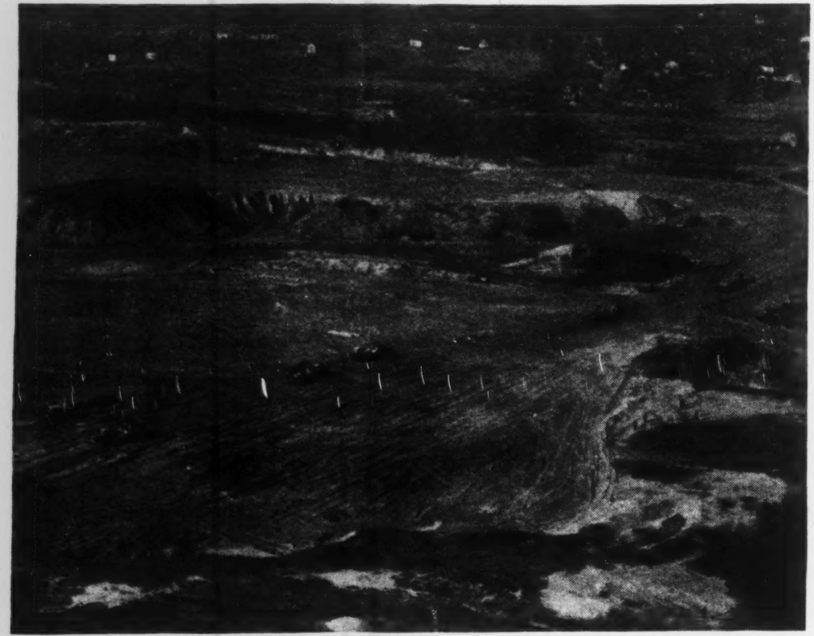


Fig. 5. Grading for Route 100 is under way near Woodbridge. In the above airview, carrying scrapers are moving earth from the wide borrowpit in the foreground to the new subgrade for the highway, which runs across the upper part of the picture, beyond the low hill.

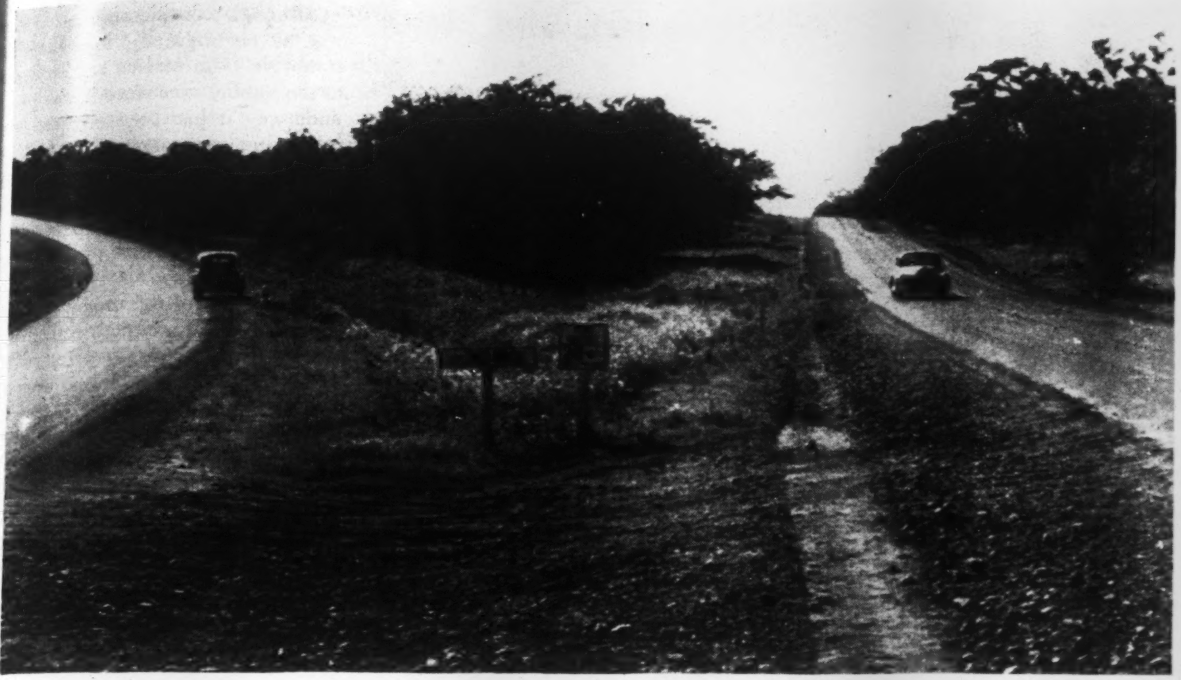


Fig. 1. Farm service roads in Texas (shown at left) combine low construction costs with maximum service.

Texas 1946 Secondary Road Program Establishes New Construction Record

Contents in Brief*—Construction of farm service roads in Texas has become big business as evidenced by the large amount of improvements accomplished during 1946. Low-cost construction is secured by standardizing bridge work and simplifying road construction.*

ALTHOUGH all the returns are not in at present, Texas is reported to be leading the 48 states in total mileage of secondary or farm-to-market highways either completed or placed under contract during 1946. In Texas, these secondary roads are designated "land-service roads." They are designed and constructed under the supervision of the State Highway Department's Land Service Road Division, which was established April 1, 1945.

Following selection of the roads to be built and establishment of their priority of construction, resulting from joint conferences of the highway commission, and the county judges and commissioners' courts of the various counties, the land-service-road program got off to a good start early in 1946.

Initial bids for this construction were received in January and the first two projects, involving 19.8 miles of new highway near Amarillo, were completed in April 1946, in a record time of 33 working days.

By the latter part of August the amount of land service roads on which construction had been completed had passed the million-dollar mark. It covered 20 projects involving 150 miles of new highways at an average construction cost of $6,660 per mile, exclusive of right-of-way. Length of projects ran from 2.6 to 17 miles.

At the same time, total contracts awarded since Jan. 1, 1946, had reached $11,440,000, covering 150 projects calling for the construction of 1,230 miles of land service roads.

By maintaining this tempo of awarding nearly $1,500,000 worth of land-service-road construction per month the highway department, up to Nov. 30, had awarded $18,520,500 worth of contracts covering the construction of 1,970 miles of new highway.

Additional work for which bids were received on Dec. 12 and 13 bringing the year's total of land-service roads placed under contract up to $19,658,000, involving 2,060 miles of new construction.

Large monthly lettings

Although great emphasis was placed on the 1946 farm-service-road program, it was not done so at the expense of the primary and urban highway programs. This is evident from

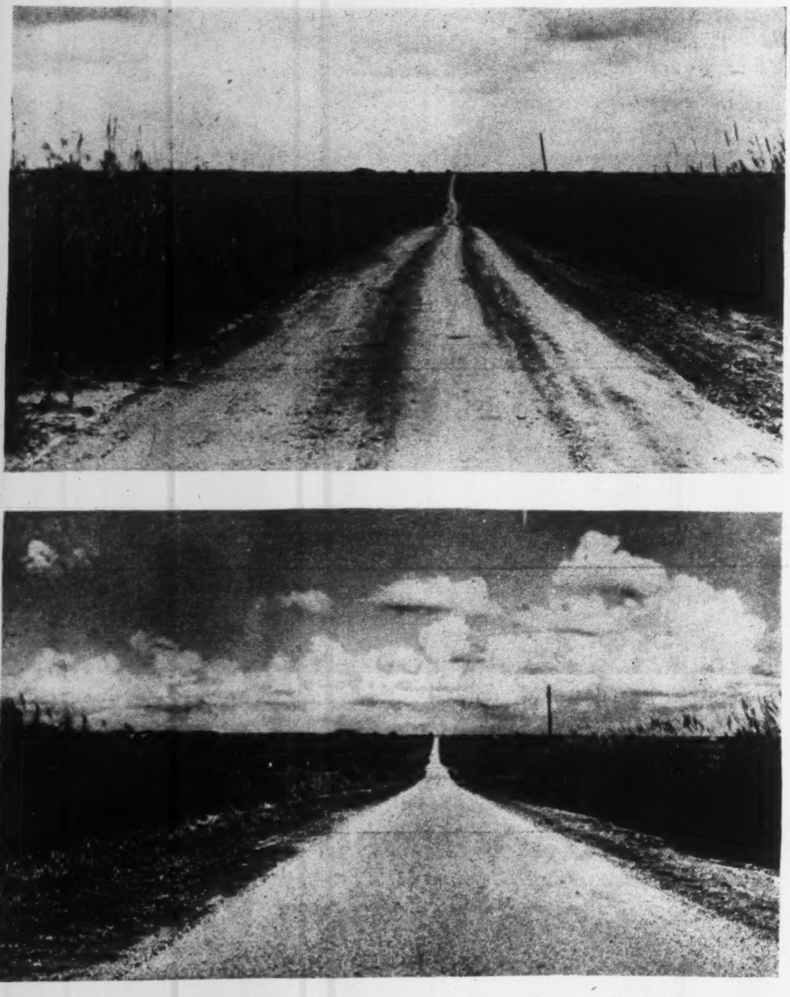


Fig. 2. Poorly-drained dirt roads (top) are converted to all-weather, armor-coated highways at reasonable cost (bottom).

the fact that for seven consecutive months starting in April the highway department let contracts in excess of $5,000,000 per month covering all types of construction including farm service roads.

Including its November letting, the highway department had placed a total of $44,000,000 worth of work under contract since Jan. 1, 1946 and the entire year's program is expected to exceed $50,000,000.

Two far-sighted factors are credited with furnishing the major impetus to the program. One was the selection and designation, in one fell swoop, of the entire 7,500-mile statewide system of farms service roads, estimated to cost $60,000,000 and to require three years for completion. The other expedient is that the counties are not required to assist in financing the work, other than furnishing the right-of-way.

Setting up the entire program in advance of the start of construction has materially simplified the detailed work of establishing the priority of construction for the 837 projects involved, located throughout 244 of the state's 254 counties. Priorities of construction for the first two years already have been established, covering 258 projects in 196 counties for 1946, and 281 projects in 186 counties for 1947.

Preparation of road and bridge plans by the state highway department, and financing the work by federal aid and state matching funds, without assistance from the counties, also has minimized the approval time on plans and permitted the program to be carried on at top speed.

Although considerable spade-work was done originally in selling the statewide farm service road program to the public, ever since it was gotten underway it has been accepted with increasing enthusiasm. In fact, 90 percent of the current requests made to the highway commission for improved roads are for farm-service roads—a true measure of the success of the program.

Completion of the three-year farm-service-road program, together with the state's $87,000,000 primary and $27,000,000 urban-highway programs for the same period, will place 16.8 percent of all Texas roads under the jurisdiction of the State Highway Department. It is estimated that these improved highways will carry 78.5 percent of all passenger car and truck traffic in the state. Moreover, completion of the total three-year program will put 62 percent of all rural dwellings within one mile, and 74 percent within two miles, of an all-weather road.

Self-liquidating program

Another feature of the Texas farm-service-road program is that it has been set up on a self-liquidating basis: i.e., costs of the improvements are expected to be replaced by revenue from motor fuel and other road-user taxes collected by the state during the lifetime of the new roads. All new roads under this program are designed for a minimum useful life expectancy of 15 years.

In general, the smaller projects are grouped as much as possible to reduce over-all cost of construction and to attract a larger number of contractors bidding on the work. Largest single project placed under contract to date is one involving the construction of a 28-mile length of new highway. The largest single contract, so far, was for $263,500, covering two construction projects.

Determining the standards of design by which the farm-service roads would be constructed posed quite a problem at the inception of the program. Obviously they could not be built to standards anywhere near those of the primary highways, due to the large mileages involved and the relatively light traffic they would carry. On the other hand, their maintenance becomes the responsibility of the highway department upon completion.

Thus, final plans were a compromise between minimum design standards and probable maintenance costs.

Special contract provisions were drafted aimed at reducing the cost of construction while at the same time providing a highway that can be expected to give useful service for at least 15 years under reasonable maintenance.

Some idea of the success in securing reasonable unit contract prices can be gained from the accompanying table which shows an average of the two low bids received for the major contract items on all projects placed under contract during the first eight months of 1946.

Selection of the width of roadway pavement for each improvement project is based not only on the present traffic, but also on its probable increase during the next 15 years. Pavement widths of 16 ft. are specified for some roads carrying less than 100 vehicles per day, particularly on connecting roads that hold little promise for increased traffic. In general, however, pavement widths are 18 or 20 ft., while some in urban areas are appreciably wider.

Roadway embankments are built in 8-in. compacted lifts, in conventional manner, while base courses, varying from 4 to 6 in. in thickness are stabilized, usually with asphalt and whatever material is the most readily available. Most of the stabilized bases are of the trench type of construction. However, several projects involve a 6-in. blanket type flexible base using gravel, crushed stone, iron-ore slag, or caliche.

All farm-service roads receive a dustless, all-weather surface; the minimum treatment being a base preservative averaging 0.30 gal. of hot asphalt per square yard covered with stone chips or pea gravel applied at the rate of 1 cu. yd. per 150 sq. yd. in surface.

Single asphalt surface treatment

Customary procedure, however, is to apply what is termed a "single asphalt surface treatment," following completion of the base course. In this method the aggregate is graded to the following requirements:

Retained on ¾-in. screen	0 percent
Retained on ½ " "	25-50 "
Retained on ¼ " " ...	80-100 "
Retained on #10 mesh screen .	95-100 "

The liquid asphalt is applied by conventional spray or traveling mix

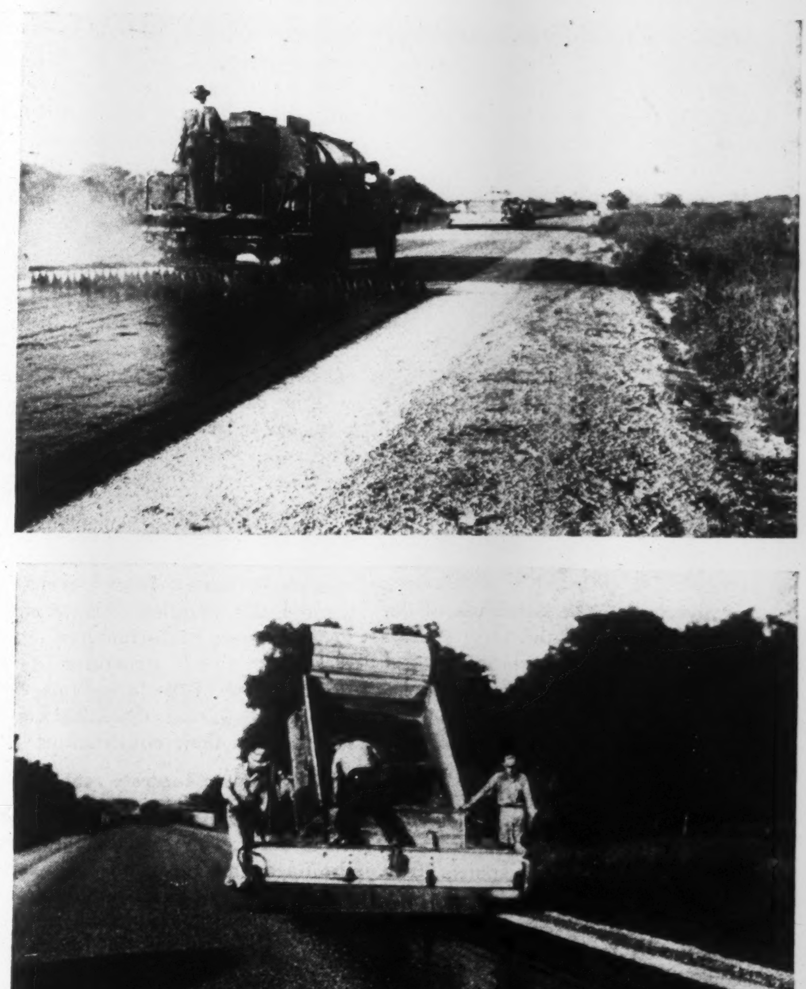


Fig. 3. Flexible pavements on stabilized bases are sealed with hot asphalt (top), given a light application of gravel (center) and rolled to a smooth crown (bottom).

method, at a rate of 0.30 to 0.50 gal. per square yard. Then, following blading to the proper crown and rolling with pneumatic-tired or three-wheel steel rollers, an armor coat of gravel or stone chips is applied at a rate of from 1 cu. yd. per 120 sq. yd. of surface, minimum, up to a maximum of 1 cu. yd. per 60 sq. yd. of surface.

On some farm-service roads carrying relatively heavy traffic, or those located in the northern part of the state and subjected to wide fluctuations in temperature, as well as appreciable snow and ice, pavement surfaces are given a "double asphalt surface treatment." This is essentially the same as a double application of the single asphalt surface treatment.

Standardized bridge plans

In developing the standards of design for bridges on the farm service roads particular emphasis was placed not only on reducing their cost of construction but also to minimize the amount of form work needed. The latter was due to the shortage of both lumber and skilled carpenters.

As a result, the standard bridge consists of a series of single 25 ft. reinforced-concrete slab spans, 20 to 24 ft. roadway, 11-in. slab and 18-in. high curbs without handrails. They are designed for an H-15 live load, except that some H-10 bridges are built on roads carrying less than 100 vehicles per day. In general, bridge roadways are 4 ft. wider than the approach pavement.

At major stream crossings the central spans often are lengthened to fit prevailing conditions. And on some of the longer structures light angle handrails have been added to give an increased sense of security to the motorist.

Bridge abutments usually are of the two-column spill-through type. Piers are either three-pile bents using a cast-in-place concrete cap on precast concrete, steel or timber piles, or two-column reinforced concrete framed bents on individual footings. Due to their relatively high cost, treated timber piles are not used to any great extent.

Reports from the field indicate that most of the intricacies of form construction have been eliminated through the adoption of these simplified concrete substructures. Also, these simplified structures permit greater reuse of the form lumber and require relatively little skilled carpenter work in their construction.

Eliminate concrete rubbing

Another point of economy in the construction of bridges and small drainage structures on farm-service roads in Texas is the elimination of rubbing the exposed concrete surfaces with silicon-carbide stones, other than the top and inside face of the curbs.

Reinforced-concrete box culvert designs for the farm-service roads also were carefully scrutinized to minimize the amount and cost of form work and to simplify their construction. One major change from formerly approved standards was to extend the wings parallel to the sides of the culvert instead of carrying them back at an angle. This considerably simplified and reduced the amount of form work.

Although the use of straight wings sacrifices some hydraulic efficiency of box culverts it facilitates their lengthening in the event of future roadway widening.

Engineering personnel

Ben B. Freeborough is engineer in charge of the Land Service Road Division, reporting to DeWitt C. Greer, state highway engineer. R. J. Lafrentz and W. F. Gustafson are senior design engineers. Bridges and drainage structures for the farm service roads are designed in the bridge office of the state highway department under the supervision of James P. Exum, bridge engineer.

TABLE OF AVERAGE UNIT BIDS

(Jan. 1 to Sept. 1, 1946)

Item	Unit	Two low bids (average)	Number of projects
Road excavation (common)	cu. yd.	$0.37	89
Road excavation (rock)	cu. yd.	1.10	26
Rolling (flat wheel)	hr.	4.24	122
Rolling (sheepsfoot)	hr.	5.02	128
Rolling (pneumatic tired)	hr.	4.08	140
Flexible base (in place)	cu. yd.	1.70	11
Flexible base (caliche)	cu. yd.	0.81	59
Flexible base (bank-run gravel)	cu. yd.	1.45	17
Flexible base (iron ore)	cu. yd.	0.98	17
Flexible base (crushed stone)	cu. yd.	1.14	9
Prime coat	gal.	0.11	65
Base preservative (asphalt)	gal.	0.12	40
Base preservative (aggregate)	cu. yd.	5.84	40
Class "A" concrete (culverts)	cu. yd.	36.40	80
Class "A" concrete (bridges)	cu. yd.	37.34	112
Reinforcing steel	lb.	0.078	176
Structural steel	lb.	0.11	30
Treated timber	M.F.B.M.	245.22	15
Untreated timber	M.F.B.M.	228.50	2
24-in. reinf. conc. pipe	Lin. ft.	4.32	51
24-in. corr. galv. metal pipe	Lin. ft.	4.09	58
16-in. precast conc. piling	Lin ft.	6.08	28
Treated timber piling	Lin. ft.	3.69	12
Steel bearing piling (12"x12" @ 53#)	Lin. ft.	5.72	24

Highway Traffic Grows Faster Than Mileage

The total mileage of all-weather rural roads increased from 387,000 in 1921 to 1,385,000 in 1941, according to Thomas H. MacDonald, head of the Public Roads Administration, and the mileage of high-type surfaced roads increased from 36,000 to 194,000. The consumption of motor fuel, on the other hand, increased six times in that period during which the mileage of all-weather roads increased between three and four times. This is explained by the increase in the use of the individual motor vehicle, amounting to about 4,500 miles per year in 1921 to over 9,000 miles in 1941.

October of this year produced the highest volume of traffic for that month ever recorded in the United States as a whole. As compared with 1945 volume, traffic in the western states is up 23 percent, in the central region 25 percent, and in the eastern states 26 percent. Traffic in seven representative cities in October of this year showed volumes well in excess of the 1945 volume, varying from an increase of 15 percent in Washington, D. C. to 34 percent in Santa Fe, N. M.

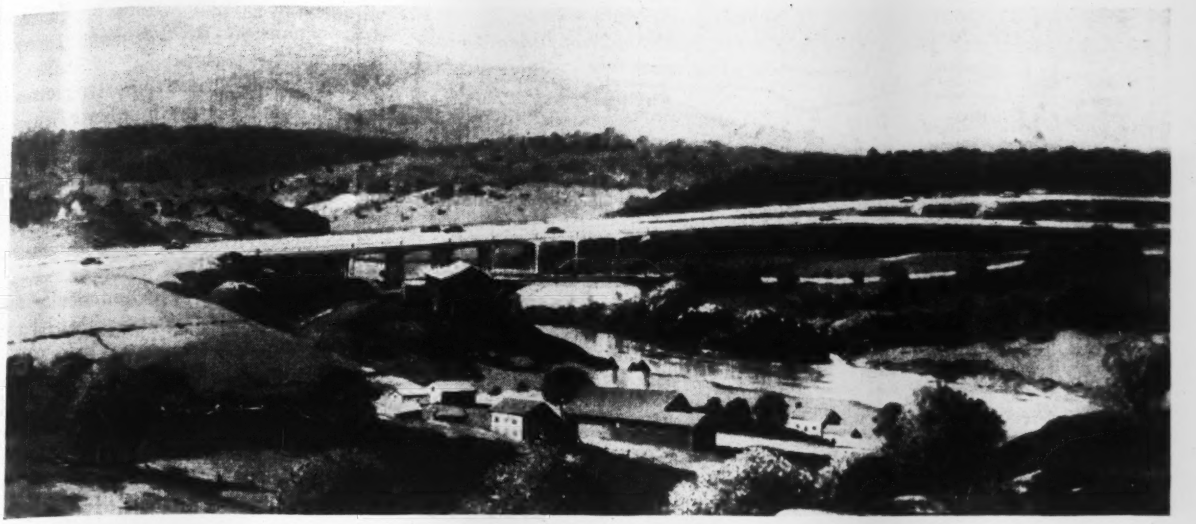


Fig. 1. This sketch of the Catskill Thruway shows how it is planned to take advantage of topography in hilly country.

New York State Builds Its Thruway

Thomas F. Farrell
Chief Engineer, New York State Department of Public Works
Albany, N. Y.

Contents in Brief*—As a major element in modernization of the highway system of New York State, a 486-mile thruway is being built from the New York metropolitan region up the Hudson Valley and across the state to the Pennsylvania line. This controlled-access highway runs close to the major centers of population, but is kept out of densely built up areas where adequate right-of-way is difficult to obtain. The best thinking of highway engineers is being applied to its design.*

NEW YORK STATE highways are undergoing a long-needed scientific face-lifting operation. With $50,000,000 worth of work placed under contract during the first sixteen months after VJ Day, the Department of Public Works is advancing its postwar highway rehabilitation program just as rapidly as necessary materials and equipment are available. The speed with which it will continue its $840,000,000 five-year program will be governed largely by the ability of the construction industry to absorb the projects it has to offer.

Nor is the state limiting its programs to the mere rehabilitation of its interurban highway system. Included in the $487,000,000 that has been earmarked for such work is a $119,000,000 allocation set aside to help uncork the traffic bottlenecks, which now so stagnate vehicular movements in cities as to endanger the economic wellbeing of many of its urban centers. Of utmost significance in the overall highway program now under way is the construction of its 486-mile thruway which will link together the Atlantic seaboard and the Great Lakes region with "The Greatest Highway in the World." In this important new highway will be incorporated all the best practices in highway design and construction.

Like Gulliver, the state has risen up, casting loose the Lilliputian lashings which, for 15 years of depression and war, prevented execution of more than token construction programs. This has been possible because, while its construction program remains largely somnolent, the Department of Public Works was constantly alert to the prodigious task which lay ahead. As a result, it had construction plans ready to pass out to the contractors the very moment the war came to an end. Nor has the $50,000,000 advance, already recorded, made a serious dent in its stockpile of projects ready for execution. This backlog of work, awaiting only the ability of the construction industry to undertake it, stands today at close to $250,000,000. And the planning continues.

The old tortuous, winding, narrow roads, built for 30-mph. motor cars, are giving way to mile after mile of modern highways capable of carrying safely the ever-increasing load of traffic which speeds across them every day. Narrow pavements, flanked by still narrower shoulders and steep

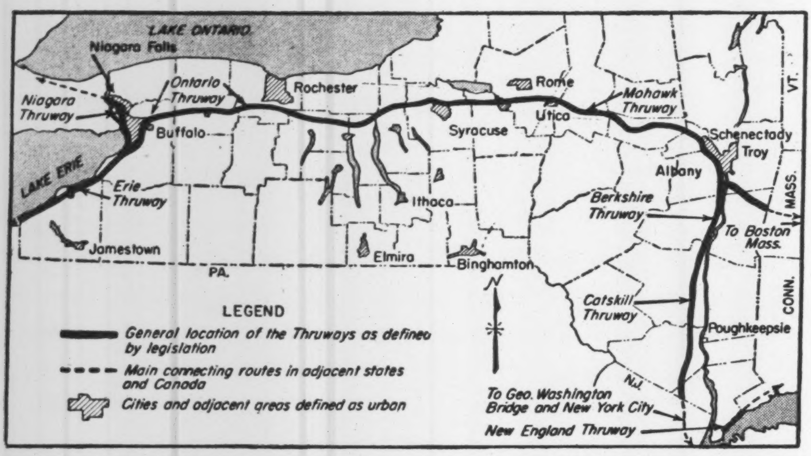


Fig. 2. New York's system of thruways has been laid out to pass near enough to the large centers of population to serve them and yet be free of the restrictions imposed by passing through densely built up areas.

V-type ditches, are being replaced by broad highways with generous and gently sloped shoulders. Sharp curves and steep grades are being relegated into the limbo of the past as long sight distances, easy gradients and greatly reduced curvatures feature new highway construction.

Unrestricted design opportunity

But it is in the design of the thruway that the highway engineer's fondest dreams find complete satisfaction. Here for the first time in the annals of modern highway construction will be a highway that will have been planned without the necessity of compromising detail with the bug-a-boos that frequently hamper the designer from building as he knows a highway should be built.

Certain rigid standards have been established to govern its construction, but these become an inspiration rather than a deterent to the engineer. The broad right-of-way, never less than 250 ft., gives him ample room in which to build. Legislation, defining the course of the thruway, is sufficiently flexible as to enable the engineers of location to select a route on which they can build well.

The idea of the thruway was conceived years ago. Its need became more and more apparent with the passing of time. Traffic on the major highways of New York State, as elsewhere, spiraled upward at a steady rate. Existing highways were reaching their saturation point. Routes 9 and 9W, connecting New York City and Albany were becoming thoroughly inadequate to meet the demands placed upon them. The same was true for Routes 5 and 20, which connected the Capital City with the thriving industrial communities of the Mohawk valley, the western plains of the state and the economically important Niagara frontier.

The region served by these highways includes the most densely populated and highly industrialized areas in the state. A belt extending about 30 miles on either side of them includes approximately one half the area of the state. But within that belt lives nearly 90 percent of the state's population and is registered about 86 percent of its motor vehicles. Concentrated in it also is the bulk of the state's industrial empire and not a small percentage of the rich farms that provide the milk and produce with which the city housewife sets the family dinner table.

It constitutes the region through which is funnelled the bulk of the interurban and cross-state commercial traffic, making it a veritable lifeline for the economy of the state. Thus it was that the importance of the region and the inadequacy of existing highways combined to dictate the necessity of improved highway facilities.

Existing roads inadequate

First consideration was given to the expansion of existing routes. It required but preliminary surveys to reveal the impracticability of such a move. While those portions of such existing routes requiring improvement are scheduled for reconstruction along modern lines, economic considerations precluded their expansion to the amount required for the region.

Because these important routes pass through a great number of cities and villages, any attempts to increase their efficiency through such expansion would involve the destruction of block after block of homes, schools, stores, churches, factories and other buildings. This would be neither socially wise nor economically sound. Natural features of terrain along some portions of the route precluded any major expansions without incurring expenses which would be greater than the cost of a new highway. From such facts it became axiomatic that an entirely new highway must be built, and the idea of thruway was born.

Planning done during war

Legislation, empowering the Department of Public Works to proceed with its construction, was passed in 1942. Wartime restrictions on construction operations precluded the advancement of any actual work on it. The war years were used, however, for the development of the standards and specifications that will govern its construction. Work was actually started on July 11, 1946, when Governor Thomas E. Dewey broke ground for the initial section at Liverpool.

Since then, five more contracts for grading and preliminary structures have been awarded. Others are being advanced for inclusion in early 1947 lettings.

These grading projects provide not only for the two 37-ft. arteries but also for the separating mall, the broad, gently sloping shoulders and the necessary drainage structures, which will insure the ultimate pavement against frostboils and uneven pavement frequently encountered at the winter's end on upstate highways.

Starts made at three points

In advancing the various projects, a set pattern has been developed. Work has been started at three widely separated points. Subsequent contract awards have been for projects contiguous with those on which work was originated. In consequence, the thruway is gradually creeping outward, in both directions, from the points at which work was first begun. Other key projects will be similarly advanced as additional focal points from which the thruway work will continue in both directions until the various projects connect to integrate the whole series of jobs into a single highway.

Determined not to let current material shortages delay the start of the thruway construction, the Department of Public Works is skipping, in initial projects, some small portions of the route where large bridges must be built and has made plans for their construction as soon as the steel market becomes less critical. In this way much of the preliminary work can be advanced at once. Grading can be completed, pavements laid and short sections opened to traffic at a much earlier date. The first paving contracts will be let within the next few months.

Easy grades and curves

Grades will never exceed three percent at any point, even in the mountainous terrain through which the southern portion of the thruway will have to course. Cuts and fills of considerable depth will be required at many places to achieve this gradient. Similar man-made alterations to other natural contours will have to be undertaken to assure a highway on which sight distances will never be less than 1,000 ft. nor radius of curvature less than the prescribed 2,800-ft. minimum.

While, quite naturally, they will be avoided wherever possible, hills and swamps will be no positive barrier to construction of the thruway. By careful, scientific study of the subterranean features and by application of the known truths in the comparatively new science of soil mechanics, it will be possible, when necessary, to overcome such barriers without any compromise with standards.

Safety and adequacy

Safety and adequacy are the two principal governing factors which have dictated the standards governing thruway construction. The safety engineers began their never ceasing efforts to reduce highway accidents by entering into the initial planning of the thruway. Working with engineers of design, they have set up safety standards that will make the highway as accident proof as man can build it. The center mall, never less than 20 ft., will keep opposing lanes of traffic far enough apart as to make head-on collisions virtually impossible. Access and egress will be limited to only those points at which carefully designed interchange facilities have been provided.

Safety planning goes ever farther at these points as provision is made for long accelerating and decelerating lanes upon which traffic, wishing to enter or leave the thruway, may safely assume the speed of traffic on the artery to which it is moving, before actually merging with it.

With access to the thruway denied from all abutting private property and with no intersections at grade with other highways, the necessity of traffic lights is eliminated 100 percent and the danger of sideswipes and other accidents resulting from merging traffic streams is avoided. Gradual undulations will relieve monotony, which can be a cause of driver fatigue.

The landscape engineer enters into

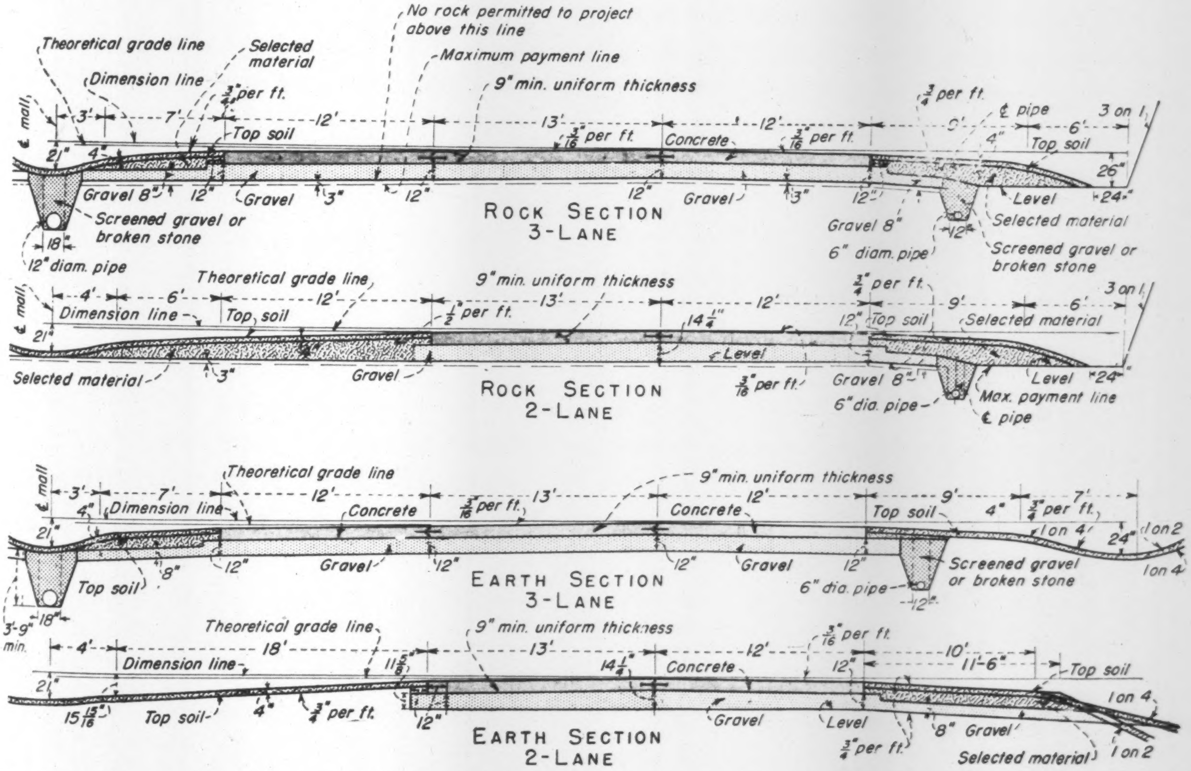

No rock permitted to project above this line
Theoretical grade line
Selected material
Maximum payment line
Dimension line
9" min. uniform thickness
$\frac{3}{4}$" per ft.
ROCK SECTION 3-LANE
Top soil
Concrete
Gravel
Screened gravel or broken stone
12" diam. pipe
6" diam. pipe
Level
ROCK SECTION 2-LANE
Max. payment line
℄ pipe
℄ mall
EARTH SECTION 3-LANE
6" dia. pipe
3'-9" min.
EARTH SECTION 2-LANE
1 on 4
1 on 2

Fig. 3. Typical cross-sections of right-hand half of the thruway. Unusual care is to be taken to provide the pavement with a substantial base which will be adequately drained.

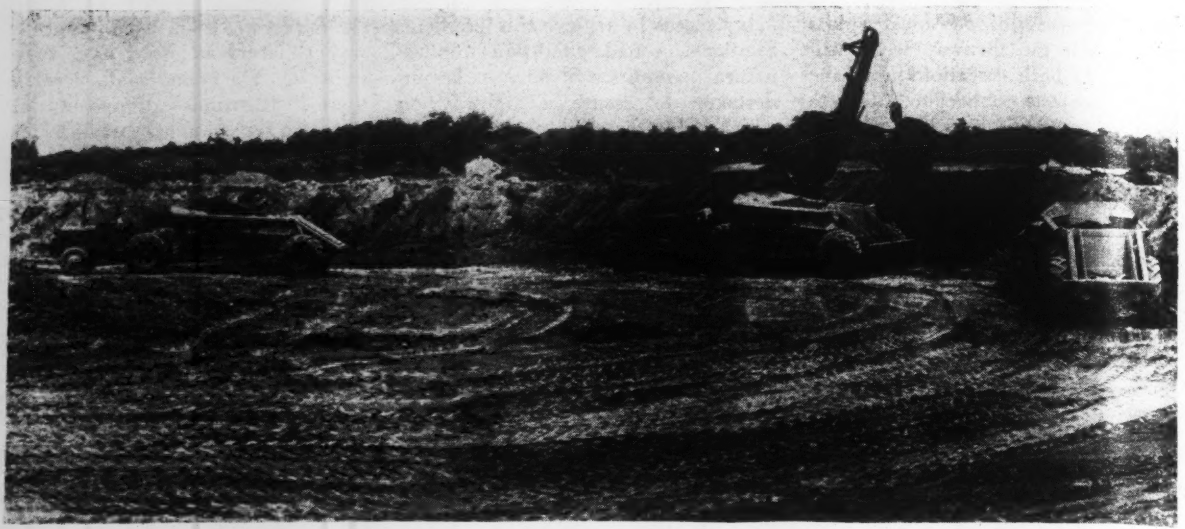


Fig. 4. Grading for the Ontario Thruway near Liverpool, N. Y. This cut is to be made in two stages of 15-ft. depth each. Cut slopes will be 1 on 4 in the lower part of the cut and 1 on 2 in the upper part to check erosion and snow drifting.

the planning phases too as he provides for the enhancement of the roadside through plantings of indigenous vegetation which will be attractive, easy to maintain and at the same time holds slopes in place to prevent erosion. He will further strive to make the thruway an integral part of the countryside by revealing the latent features of the natural beauty of the lands through which it passes by occasional pruning or planting as need may dictate. The outdoor advertisers have already joined hands with him to help make the thruway more attractive by a voluntary agreement on their part to refrain from the erection of displays along all noncommercial regions it transects.

Then too, the safety and landscape engineers will combine their talents, where needed, to provide whatever plantings that may be required on malls to screen out opposing headlights on curves. The work of the landscape engineer will be further reflected in the development of wayside picnic areas at conveniently located, attractive spots along the thruway route.

Designed for stability

The design of the thruway calls for ultimate construction of two 37-ft. arteries for each direction. Cross sections of the proposed design of these are shown in Fig. 3. Actual construction operations are preceded by thorough analyses of subsurface conditions in order to assure stable roadbeds which can support the new pavement without fear of erosion, ground settlement or frostboils.

Pavements to be laid on the newly graded rights-of-way will be 9-in. concrete, capable of sustaining any vehicle that may legally use the highway. The H20-S16 design loading for thruway bridge structures will result in greater carrying capacity than is required for structures on the regular highway systems and for which the H20 theoretical loading is standard.

Free movement at bridges

The design of thruway bridges has been based on freedom from either physical or mental obstructure to the free and easy flow of fast-moving vehicular traffic. It has been recognized that there must be an aesthetic relationship between the open thruway and the necessary locations to carry the twin arteries over streams, as well as over or under intersecting streets, highways, parkways and railroads. The basic consideration, however, has been unobstructed movement.

In accomplishing the basic concept, every effort has been made to utilize deck structures of varying types for all highway traffic. Where it is necessary to carry the thruway under a railroad or intersecting traffic movement, wide clearances are called for to the faces of abutments and to the pier faces in center mall.

A typical cross-section of a thruway passing under a structure will have a 10-ft. clearance from the face of an abutment to the edge of the nearest lane. There will then be developed 37 ft. of concrete pavement consisting of a 12-ft. lane, a 13-ft. lane, and another 12-ft. lane. A clearance of 6 ft. as a minimum will be established to the face of the pier in the center mall. This will be followed by the width of the pier about whose center line the thruway section is symmetrical. Since the minimum width of the center mall is 20 ft., this gives a total width, face to face of abutments, of 114 ft. This width between abutments will, of course, be greater if, in addition to the six traffic lanes, it is necessary to carry an acceleration or deceleration lane under the structure.

Special treatment of the mall

Since the center mall is to be depressed and will accept drainage from the pavement surface, it can be easily seen that considerable care must be taken in the development of the design so that the finished structure, including the center pier, properly fits into the thruway and does not in any way interfere with drainage of the pavement surface. In general, drainage will be picked from the center mall adjacent to the pier face on its up-hill end and carried to the sides of the road or, where this is not practicable, it will be carried under the mall section parallel to the pier on one or both sides of the pier.

depending upon the volume of water present.

A typical cross-section of a structure carrying the thruway will consist of the parapet and railing with a 30-in. safety walk and a 6-ft. slab between the face of the curb on the safety walk to the edge of the pavement. There will then be three lanes of pavement in a total width of 37 ft., a 6-ft. distance from the edge of the pavement to the face of the curb on the slightly raised center mall, which will be 8 ft. wide, and about whose centerline the bridge deck will be symmetrical. This produces a total distance, face to face of curbs, of 106 ft.

Again it is to be noted that considerable care must be exercised in the design to develop the depressed mall on the approaches into a proper introduction to the bridge head, where the mall is elevated, to produce a pleasing appearance and properly take care of drainage conditions existing at this point. Since curbs will not be used on the standard thruway section, there must, of necessity, be a considerable amount of attention and care paid to the method of interjection of the raised mall across the bridge to produce a satisfactory, usable structure as well as one having a proper appearance.

Grade separation structures

In general, two or three main-span structures will be utilized throughout for the grade separation structures that pass over the thruway. Since it may be desirable to vary the width of the mall, due to topographical conditions or for other reasons, it may be necessary, on occasion, to utilize modified forms of these structures. This will be particularly true where the mall width is increased from 20 ft. to as much as 50 or 100 ft. Modification of the design will be accomplished by increasing the clearance from the pier face to the edge of the inside lanes through an increase in the length of span over the pavement lanes up to 85 ft., with an outside limit of approximately 100 ft. Beyond this limiting point the increased width of the mall will be taken care of by reducing the length of the two spans over the pavement and introducing a correctly proportioned intermediate span over the mall section to obviate the need for a solid walled section across the mall between the main spans.

It is contemplated that structures will be built of reinforced concrete or of steel. In all instances, considerable thought has been given to the aesthetic utilization of steel superstructures, where they are desirable, throughout the thruway. There are locations where rigid frames of either reinforced concrete or steel may be economically and aesthetically developed. The multiple span structures of the steel-beam type, whether of the rolled or made-up section, will generally be recognized as functioning with the slab under composite action.

The width of the intersecting streets, highways or parkways will govern the width of the structure developed over the thruway, after full consideration has been given not only to the present usage as revealed by studies of existing traffic movements, but in consideration of the usage that will be present in 20 years predicated upon a careful analysis of the development of the locality. These structures will not only provide the width of pavement to properly carry the traffic but will also have wide clearances from the edge of the pavement to the curb in conformity with the standards established by the Department of Public Works for its highway usage on other than thruway routes. In no instance will any of these structures be designed without proper pedestrian facilities, regardless of their location.

Stream crossings

The type of stream bridge depends entirely on the character of the stream, together with the character of the underlying material present at the site on the stream crossing. It still is the intention of the department to utilize all-deck structures for stream crossings as well as for grade separation, even to the breaking up of the longer spans, if this is found necessary and can be accomplished as a recognition of proper stream discharge and usage. A description of the first of these bridges to be designed in detail was published in *ENR* Dec. 26, 1946, vol. p. 856.

The highest degree of engineering skill will go into every phase of thruway construction. No aspect will be overlooked from subsurface, to pavement, to structures and to the right-of-way. Carefully designed, well-built and adequate to provide means of fast, safe transportation for the people of New York State and their motoring guests, the thruway is certain to be worthy of its designation as "The Greatest Highway in the World."

Expenditures on Highways Declined in Recent Years

Although there has been a tremendous increase in highway usage in recent years, highway expenditures have been declining for a considerable period. This fact was reported to the recent meeting of the American Association of State Highway Officials by Thomas H. MacDonald, Commissioner of Public Roads, who said that it may come as a surprise to many that the period from 1927 to 1930, with an annual average of $2 billion for all highway and street purposes was the peak period of highway development. He gave the following figures as the total amount for construction, maintenance and administration of highways from 1923 through 1942, divided into four-year periods.

1923-1926	$5.9 billion
1927-1930	8.0 "
1931-1934	6.6 "
1935-1938	7.5 "
1939-1942	7.4 "

Mr. MacDonald also gave the following figures to indicate the serious lag in replacement of federal-aid highways. Recent inspections show that of the 187,557 miles of such federal-aid highways, 27,218 miles, or 14.5 percent, are in a condition requiring reconstruction. Assuming that this ratio holds on the 547,285 miles of other highways maintained by state highways departments, there would be 65,000 miles in need of reconstruction. Mr. MacDonald added that the seriousness of this situation is indicated by the growth of maintenance costs to approximately $750 million the year 1946.

On the showing that the desirable safe capacity of a two-lane road is 3,000 vehicles per day, on an annual average, there are in the neighborhood now 14,000 miles that need to be stepped up to the four-lane design, and these inadequate highways are on the main-traveled route of the state.

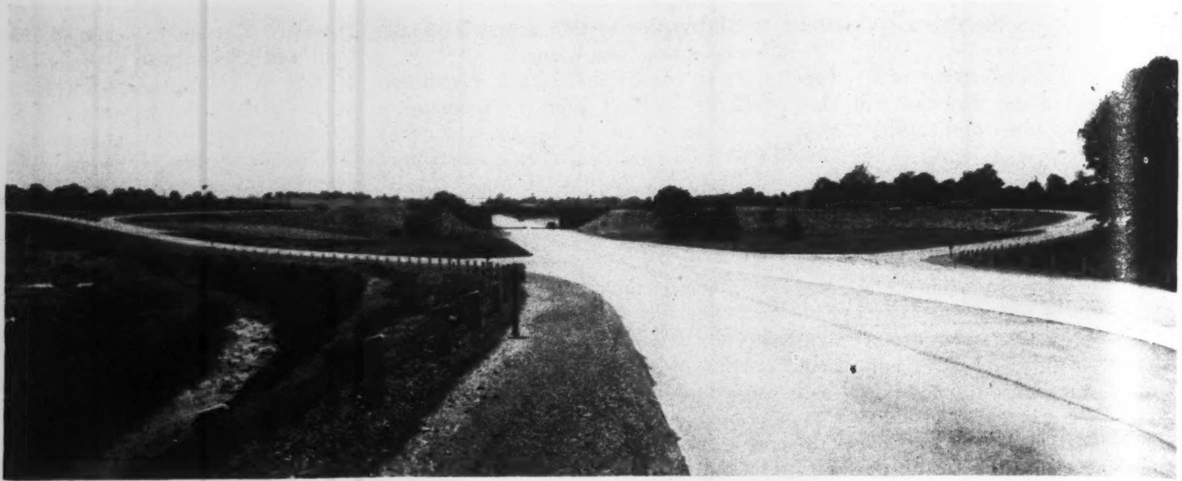


Fig. 1. Grade separations in urban areas such as this one on the four-lane divided highway on U. S. Highway 22 east of Harrisburg, Pa. require extensive right-of-way and a high degree of design for the free-flow of interchange traffic.

Have Highway Costs Reached Their Peak?

Editor's Note*—Throughout 1946 the "high cost of highway construction" resulted in many rejected bids and in some quarters threatened to throttle the postwar highway program. Admittedly the cost of road building, which jumped sharply between VJ-Day and the end of 1945, continued its upward swing into 1946. But where does it stand today, and where is it apt to go from here? To get a cross-section of price trends throughout the country, ten highway departments were asked to report on their present contract costs and unit price trends. Their reports, together with a year-end statement from the Public Roads Administration are presented in the following.*

HIGHWAY construction costs, which rose 30 percent above 1940 prices between VJ-Day and the end of 1945, continued their upward spiral until today a conservative estimate is that the cost of highway construction is from 50 to 55 percent above 1940 prices. Thus current average prices have advanced from 15 to 20 percent above those prevailing in January 1946.

Labor is blamed chiefly for this sharp increase in the cost of highway construction—not only its increased wage rates, but the elusive factor of labor inefficiency, upgrading of less-skilled workmen to higher wage brackets, scarcity of skilled craftsmen and excessive amounts of overtime work required to keep construction on schedule—all have contributed to the production of less construction per payroll dollar.

From the labor standpoint there seems to be little likelihood of any reduction in the cost of highway construction during 1947. However, some states, notably Texas, report an overall leveling off to contract prices during the latter part of 1946.

Just how decisive a bearing the productivity and cost of labor have on the contract prices of various construction items is clearly shown by the fact that, in general, those items involving the greatest proportion of labor have increased the most in price.

Bridge items increased the most

This is particularly evident in bridge construction where Oregon reports and 80-percent increase in prices over prewar costs, and North Dakota follows close behind with a 70 percent increase. As might be expected, the cost of structural concrete has increased the most percentage-wise—ranging from 85 to 152 percent above 1940 prices. Reinforcing steel and structural steel, both of which require considerable erection labor in addition to increased fabrication costs, have increased an average of 65 and 75 percent, respectively, over 1940 prices.

Contract items that are adaptable to mass construction methods employing relatively little labor and a maximum of mechanical equipment and improved techniques showed the least increased costs. Prominent in this category is common, or earth, excavation. While one state did report an increase of 127 percent in the cost of this work, over 1940, others reported increases as low as 23 percent—with an eight-state average of only 53 percent.

Portland-cement concrete pavement, bituminous concrete and asphalt surfacing—all of which are constructed largely by mechanical operations—were well down the list in cost increases. With the exception of one state, which reported the cost of portland-cement concrete pavement had risen from 60 to 100 percent over 1940 prices, the price range of this contract item is from 19 to 79 percent above prewar prices, with an eight-state average of 48 percent.

Bituminous concrete was reported

to have increased in price since 1940 by a low of 11 percent to a high of 66 percent. One state highway department — Michigan — reports that the current cost of asphalt resurfacing is only three percent over what it was in 1940.

Short cuts of economy

Despite the unprecedented increases in highway construction costs following VJ-Day and continuing into 1946, as shown in the several accompanying tabulations of comparative contract prices, the state highway departments waged an endless fight against spiraling costs. How much higher highway costs would have risen had these precautions not been taken is a moot question.

Many construction refinements formerly considered indispensable to good highway construction were modified, or even eliminated, in the interest of economy. Notable examples of this economy were the elimination of rubbing exposed concrete surfaces with abrasive stones, increasing the permissible depth of "lifts" in constructing roadway embankments, and the reduction of compaction requirements of subgrades on highways carrying medium-heavy or light traffic.

Economy of construction was of paramount importance to the farm-to-market highway program, particularly in view of the large mileages involved and the comparatively small amount of funds available for the work. Small projects often are grouped under one construction contract to reduce costs of moving equipment to and from the job, and to provide a full season's work for the contractor.

Low-cost farm-to-market bridges

Particular attention was given to designing low-cost bridges and small drainage culverts on the farm-to-market program. In several instances standard bridge plans were developed aimed at the maximum reuse of form lumber, which continued scarce throughout 1946, and a minimum amount of skilled carpenter work.

Five states reported building farm-to-market roads costing less than $17,000 per mile, including grading, drainage structures and the construction of an all-weather surface, usually of bituminous material. Texas, with over 2,000 miles of farm-to-market roads either completed or placed under contract during 1946, reportedly led the 48 states in this field of highway work. Its cost of farm-to-market road construction averaged $9,200 per mile, while Virginia builds its farm-to-market roads at an average cost of $10,000 per mile.

Despite the scarcity of men, materials and equipment, the ever changing wage rates, and the uncertainty of cost of materials, the highway engineers watched the mounting costs of construction to see that they did not get out of line. Many low bids were rejected as being too high compared with the engineers' estimates. In dollar volume the amount of low bids rejected ranged from 5 percent of the total program in California to a high of 30 percent in Illinois.

By analyzing the construction conditions involved and revamping the work to eliminate as many of the uncertainties of prosecuting the work as possible, most of the projects on which bids had been rejected, subsequently were readvertised and contracts awarded.

Based on the dollar volume of work placed under contract, the 1946 highway program came up fairly well to expectations. As reported in the Dec. 26 issue of *Engineering News-Record*, vol. p. 853, highway construction of all classes placed under contract during 1946 aggregated $769,387,000, exceeding the 1940 program by 10 percent. Bridge contracts for the entire country during 1946 totaled $128,671,000. By comparison, a poll of 44 states made in December 1945 showed an anticipated state highway construction program, including bridges, for 1946 of nearly $800,000,000 (*ENR* Jan. 10, 1946, vol. p. 37).

The total mileage of new highway constructed in 1946, however, is somewhat less than was programmed. This is readily understood in view of the increased construction costs. Reports from seven highway departments disclose that the cost of two-lane cement concrete pavement including grading and a nominal amount of drainage structures ranges from $60,000 to $103,000 per mile; with an average for the seven states of slightly more than $75,000 per mile.

Believe peak has been reached

Although the economic picture of current highway construction, as outlined in the following reports from ten state highway departments and the Public Roads Administration, is unclear, nevertheless a belief exists in some quarters that the peak of highway construction cost has been reached. Whether or not this is true should become evident as the 1947 construction program gets under way in the coming spring.

Illinois Rejected 30 Percent of Low Bids During 1946

W. W. Polk

Chief Highway Engineer, Springfield, Ill.

An examination of all bids received during 1946 by the Division of Highways, of the Illinois Department of Public Works and Buildings, shows the low bids were 105.75 percent of the engineers' estimates. During that year, low bids for highway construction amounting to $6,750,000 were rejected. This was approximately 30 percent of the total low bids received during the year.

Illinois no longer is using thickened edges for its portland-cement concrete highway pavement. Moreover, the pavement fabric used for reinforcement has been increased from 54 lb. per 100-sq. ft. in 1940 to 78 lb. per 100-sq. ft. Consequently, no direct comparison is shown for these two items in the accompanying tabulation (Table I) of comparative costs of unit bid prices for some of the state's major contract items.

Concrete pavement up 44 percent

Based on 1940 prices, however, the 9-in. uniform thickness concrete pavement would have cost $2.36 per sq. yd. Thus, current costs of this pavement have been increased 44.1 percent over 1940 prices. Similarly, the 1940 cost of pavement fabric based on the new weight of 78 lb. per 100-sq.ft. would have been $0.277 per sq. yd. Today's prices of $0.37 per sq. yd. shows a 33.6-percent increase in the cost of this item.

Although current costs of contract items have risen sharply over those of 1940, not all have continued to rise during the past year. For instance, as shown in the table, the cost of reinforcing steel has dropped 4.6 percent since January 1946 and that of structural steel has been reduced by 18.4 percent for the same period.

Some idea of the cost of highway construction in Illinois can be gained from the following current costs for the various types of pavement and surfacing. These costs include grading and small drainage structures.

Portland-cement concrete pavement, 22 ft. wide and 9 in. thick, and reinforced with wire fabric, costs from $60,000 to $80,000 per mile. Three-inch bituminous concrete resurfacing, 18 ft. wide, costs $19,000 to $21,000 per mile. Another type of improvement used considerably in Illinois, consisting of a 22-ft. width of 3-in. bituminous concrete resurfacing, plus 2 ft. of portland-cement concrete base widening costs from $31,000 to $37,000 per mile.

Gravel or crushed stone surfacing, 4 in. thick and 24 ft. wide, costs $20,000 to $30,000 per mile. A more permanent type of surfacing, involving a 22-ft. width of gravel or crushed stone 7 in. thick, in which the top 2 in. are bituminous treated, costs $25,000 to $45,000 per mile.

TABLE I—COMPARATIVE BID PRICES FOR BASIC CONTRACT ITEMS IN ILLINOIS

		Unit Bid Prices			Current Increase Over 1940 Prices (percent)	Increase during 1946 (percent)
Item	Unit	1940	Early 1946	Current Cost		
P.C.C. Pavement (9–7–9-in.)......	sq. yd.	$1.99	......	......	....	
Pavement fabric (54#/100 sq. ft.)..	sq. yd.	0.192	......	......	....	
P.C.C. Pavement (9-in. uniform)..	sq. yd.	......	$3.00	$3.50	....	16.7
Pavement fabric (78#/100 sq. ft.)..	sq. yd.	......	0.32	0.37	....	15.6
Earth excavation................	cu. yd.	0.281	0.32	0.40	42.4	25.0
Class "X" concrete.............	cu. yd.	24.69	50.00	60.00	143.0	20.0
Reinforcing steel................	lb.	0.045	0.087	0.083	84.4	−4.6
Structural steel..................	lb.	0.05	0.109	0.089	78.0	18.4

Texas Awards Highway Contracts At an Even and Rigorous Tempo

Engineering Staff,
Texas State Highway Department, Austin, Tex.

At the close of the 1946 calendar year, the Texas Highway Department had awarded since VJ-Day contracts totaling a little more than $65,000,000. Contractors apparently have found means of meeting the manpower and material shortages and are seeking new jobs about as rapidly as they are offered for bids. We have compensated for delays due to slower delivery of critical materials by allowing more working time.

Texas therefore has been able to maintain the desired schedule of lettings and to advance programs at an even tempo at prices considered to be competitive and not excessive under prevailing conditions. Whether we can continue our future construction programs on the same magnitude of scale now appears dependent in most part on the ability of the department's limited engineering personnel to make surveys and plans for new projects and at the same time give proper supervision to construction work that now is under way.

In making a study of current prices and the availability of contractors, this state has compared the first nine months of 1946 against the same period in 1940 and found that the average number of bids per project dropped from 6.7 in 1940 to 4.2 in 1946. To be considered, however, is the fact that a much larger construction program was undertaken in 1946. For the respective periods, 377 projects were advertised last year as against only 256 in 1940. Actually, there is very little difference in the total number of bids received for both periods.

On the basis of a comparable number of contractors and their ability to do work, competition in 1946 on desirable work was practically as keen as in 1940. There is, however, a greater tendency on the contractor's part to select the work on which he wishes to bid. A large number of bids will be received on projects which are considered attractive, but very few or no bids at all will be received on projects presenting unusual difficulties to the contractor.

It has been difficult to secure representative prices on any project involving bad soil or climatic conditions or on any project requiring a long-time commitment on the contractor's part. It has proved to the state's interest to rework plans for projects on which satisfactory bids were not received to correct conditions considered hazardous by the contractor and

TABLE II—COMPARATIVE BID PRICES FOR BASIC CONTRACT ITEMS IN TEXAS

		Unit bid prices			Current increase over 1940 prices (percent)	Increase during 1946 (percent)
Item	Unit	1940	January 1946	Current 1946		
Roadway excavation:::...	cu. yd.	$0.24	$0.36	$0.39	62	8
Flexible base............	cu. yd.	0.535	0.80	0.884	65	10
Additional quarter-mile haul.................	cu. yd. per ¼-Mi.	0.016	0.031	0.028	75	−11
Asphalt surface treatments	gal.	0.086	0.099	0.113	31	14
Aggregate..............	cu. yd.	3.53	5.43	5.30	50	−2
Bituminous conc. & rock asphalt..............	ton	5.12	7.00	6.11	19	−13
Concrete pavement......	sq. yd.	1.67	2.20	2.60	55	18
Reinforcing steel........	lb.	0.045	0.058	0.079	76	36
Structural steel..........	lb.	0.067	0.081	0.101	51	25
Structural concrete......	cu. yd.	19.60	30.430	37.97	93	25

to permit the letting of separate contracts in stages for grading and small structures, large structures and surfacing.

As evidence of the success of this procedure, of the total of $65,000,000 offered for bids during the past eleven months, no bids were received on an accumulated total of $3,000,000 (5 percent) and bids were rejected on $6,000,000 (10 percent). By reworking the plans and adopting stage construction to avoid long-time commitments, all work on which satisfactory bids were not subsequently received is now estimated to cost less than $3,500,000. The majority of projects making up this latter total are located in coastal areas which have both poor soils and wet weather.

Bid prices are leveling off

In our analysis of construction costs, we find that the upward trend in 1945 continued through February, 1946, but that from February to the present time there has been an overall leveling off of prices. The accompanying tabulation (TableII) gives a comparison of current bid prices on some of the basic contract items with 1940 prices and those of January 1946.

Bids received in November and December, 1945, showed a 52-percent increase over 1940 prices, and prices continued to increase to 66 percent over 1940 prices in February, 1946. Thereafter, prices have fluctuated monthly from a low of 56 percent to a high of 81 percent, depending on the desirability of the projects offered for bids. However, the overall average of 66 percent in excess of 1940 prices has held for the year as a whole.

From a study of the individual important contract items, we find a fairly uniform increase of prices in January, 1946, over those in 1940. Upon comparing the January, 1946, prices with those received at the end of 1946, we find that the fairly stable overall construction cost for the year is the result of the decreased costs of some items counteracting the continued upward trend of others. With these facts at hand, the state has been able to estimate the majority of projects within three percent of the contract cost.

Current costs of building a one-mile section of the various types of primary highways in Texas, including an average number of minor drainage structures are as follows: (1) Grading and structures, $20,000 to $35,000; (2) Grading, structures, base, and intermediate type surface, $35,000 to $50,000; and (3) Grading, structures, and higher type pavement such as portland-cement concrete or asphaltic concrete on flexible base, $45,000 to $75,000. Average cost of farm-to-market highway construction, including grading, structures, flexible base and light asphalt surface treatment, is $9,200 per mile.

Pennsylvania Highway Costs Have Doubled since 1940

Bid prices of many of the items making up the major part of Pennsylvania's highway-construction cost have practically doubled since 1940. Statistical verification of this statement will be found in the table of costs (Table III) where it may be noted that the low to high range of prices for 1946 are, item for item, almost exactly twice that of 1940.

There are many reasons for the increase. Labor probably is the largest single item. The average hourly rate paid on contract work on Pennsylvania's roads in 1940 was only $0.493. In 1945 it was $1.234, with a similar average expected for 1946. But increased average wage scales account for only part of the difference in labor costs. Multiple pay for overtime was limited to a few crafts and localities in 1940. Now it is a necessity for all work over 8 hours a day or 40 hours per week. Moreover, the elusive item of efficiency of labor also plagues contractors who have difficulty moving an experienced crew due to housing shortages and hence seldom develop a smooth working team.

Many bids rejected

During the first eleven months of 1946, Pennsylvania awarded $42,000,000 worth of construction contracts for grading, drainage, paving and for substructures only of major bridges. Some $28,000,000 in construction bids were rejected, while on $8,000,000 worth of work offered no bids were received.

Contractors have been most competitive on moderate sized jobs of not more than six months duration. Lettings were suspended late in the fall of 1946 as it was found that bids for work to be done this spring were not in line with those being received for immediate work. In some instances where word had gotten around that no contractor was particularly interested in a specific project, the bid prices frequently have been high with only one, or at most two bidders. But these bids seldom have resulted in an award, since the Pennsylvania Highway Department uses a realistic system of estimating actual costs of specific projects instead of adding percentages to average job prices.

Two independent estimates made

Cost estimating is done independently by two agencies of the highway department, after which the results are compared and justified. The district engineer office in the area where the job is located makes an estimate on the site where full knowledge of all local conditions is available. At the same time an estimating and cost section of the department in the Harrisburg office, with information at hand on cost trends, past records and general conditions frequently not available to field offices, make a separate determination.

Neither of these estimates is made public either before or after a letting but each is used confidentially by the department. They are available for discussion with contractors when it is considered that bids are too high and they usually form the basis for refusal to make an award. That the state-made estimates are given considerable weight by the awarding executives is evidenced by the fact that the $42,000,000 worth of work placed under contract during 1946 averaged two percent *below* the engineers' estimate while the $28,000,000 rejected average 15 percent *above*.

Bridges requiring structural steel are being let for substructure work only, to comply with Public Roads Administration regulations. Steel mills in Pennsylvania insist that the

TABLE III—COMPARATIVE BID PRICES OF MAJOR CONSTRUCTION ITEMS STATE HIGHWAY CONTRACTS IN PENNSYLVANIA FOR 1940 AND 1946

Figures for 1946, shown in bold face, are for eleven months only.

Item	Unit	Quantity 1940	Quantity **1946**	Av. cost per unit 1940	Av. cost per unit **1946**	Increase over 1940	Bid range per unit 1940	Bid range per unit **1946**
Roads, including minor structures								
Roadway excavation	cu. yd.	16,320,000	**8,641,000**	$0.436	**$0.868**	99%	$0.23–1.60	**$0.49–4.00**
Structural and misc. excav	cu. yd.	327,000	**258,000**	1.622	**3.333**	105	0.60–5.00	**1.25–12.00**
Subgrading	sq. yd.	6,000,000	**2,706,000**	0.105	**0.232**	106	0.07–0.30	**0.12–0.60**
Shoulders (both sides)	lin. ft.	2,320,000	**1,560,000**	0.156	**0.326**	104	0.08–0.48	**0.15–1.00**
Crushed agg. base course, 8 in	sq. yd.	710,000	**359,000**	0.797	**1.869**	134	0.60–2.00	**1.25–5.25**
Plain concrete base, 8 in reinf	sq. yd.	73,000	**144,000**	2.420	**4.424**	75	1.70–5.00	**3.55–5.20**
Conc. pavement, 8 in. reinf	sq. yd.	740,000	**13,150**	2.199	**4.373**	103	1.86–3.00	**3.65–10.00**
Conc. pavement, 9 in. reinf	sq. yd.	1,024,000	**1,792,000**	2.517	**4.024**	60	2.30–3.50	**3.40–7.00**
Conc. pavement, 10 in. reinf	sq. yd.	17,000	**58,600**	3.026	**5.051**	67	2.77–3.90	**4.90–8.50**
Bituminous surface material	tons	62,000	**82,000**	6.002	**8.683**	45	5.15–12.00	**6.30–20.00**
Bitum. surface, 2 in. two-course	sq. yd.	501,000	**231,400**	0.750	**1.245**	66	0.40–1.50	**1–3**
Bitum. surface, 3-in. single course with seal	sq. yd.	697,000	**202,000**	0.720	**1.158**	61	0.46–1.10	**0.90–1.70**
Bitum. surface treatment	sq. yd.	262,000	**363,000**	0.328	**0.521**	59	0.20–0.94	**0.45–2.00**
Conc. for structures 1:2½:4½	cu. yd.	86,000	**44,000**	18.51	**39.023**	110	11–40	**20–100**
Structural steel, plain	lb.	1,500,000	**598,000**	0.048	**0.090**	88	0.035–0.15	**0.08–0.20**
Structural steel, fabricated	lb.	7,034,000	**3,782,000**	0.061	**0.098**	61	0.05–0.11	**0.075–0.27**
Plain steel bars	lb.	6,882,000	**3,989,000**	0.045	**0.081**	80	0.035–0.25	**0.06–0.15**
Cement rubble masonry	cu. yd.	28,000	**9,000**	12.80	**34.667**	130	10–40	**15–55**
Inlet, cast-in-place concrete	each	365	**221**	81.58	**158.371**	94	30–175	**83–330**
Reinf. concrete pipe, 15 in	lin. ft.	63,000	**49,000**	2.405	**3.898**	62	1.60–5.50	**2.50–8.00**
Items bid on larger bridges								
General excavation	cu. yd.	1,305,000	**1,682,000**	0.451	**0.746**	66	0.26–3.00	**0.63–2.25**
Structural and misc. excav	cu. yd.	131,000	**45,700**	2.048	**3.829**	87	1–10	**3–6**
Conc. for structures, reinf	cu. yd.	27,000	**12,500**	22.55	**51.04**	128	15–42	**40–87**
Conc. for structures, mass	cu. yd.	67,000	**18,600**	16.97	**42.86**	152	13–40	**31–84**
Plain steel bars	lb.	7,331,000	**2,092,000**	0.044	**0.076**	73	0.035–0.10	**0.07–0.10**
Structural steel, fabricated	lb.	20,552,000	**4,715,000**	0.062	**0.095**	53	0.04–0.22	**0.09–0.12**
Treated lumber	M. ft.	596	**4.35**	104.30	**252.87**	142	90–200	**200–520**
Concrete piles 14–26 ft. long	lin. ft.	24,000	**678**	2.25	**5.90**	162	1.60–4.15	**4–8**

heavy structural steel required for bridges will not affect materials needed for housing, but the government has been adamant in refusing authorization.

Labor, except carpenters, has been generally available for Pennsylvania highway construction, but quality and willingness to work have been generally lower than should reasonably be expected. Concrete structures have been delayed by lack of qualified carpenters with the situation improving only slowly, if at all.

Inefficient Labor Caused High Construction Cost in Georgia

G. T. McDonald

Engineer-Director, Georgia State Highway Department

Scarcity of construction materials and the difficulty in securing sufficient quantities of them to carry out the Georgia State Highway Department's expanded road building program were prime factors in raising the cost of construction during the past year. With the uncertainty of delivery of materials, contractors were forced to make cost allowances which were reflected in their over-all bids. This condition eased somewhat during the latter part of the year and it was reflected in some stabilization of costs with the trend pointing downward as the year drew to a close.

Material price increases were not as substantial a factor in total costs of construction as was labor and its efficiency. For the most part, common and semi-skilled labor had enjoyed relatively high wages in war work and there was evidence of reluctance to return to heavy road work. Common labor, which had received 30c. per hour before the war, received 65 and 75c. per hour during the past year.

This increase in wages, however, would not have added too heavily to the total cost if efficiency had kept pace with rising labor costs. It was found in most instances that it required two laborers to accomplish what one did before the war, due chiefly to the class of labor available for the work. Also, most workers in the common-labor class would not work on Saturdays. Because of the shortage in this category, many semi-skilled workers had to be used as common laborers.

Labor was inefficient

The attitude of common labor was reflected in other classes. There had been a general letdown in the mental attitude of the worker following VJ-Day, and there was an apparent lack of incentive to hustle the job along and to accomplish it with a pride of skill. The attitude was one bordering on a deliberate slowdown in order to stretch out the work. It was one of "take it easy."

Another factor tending to increase

TABLE IV—COMPARATIVE BID PRICES FOR BASIC CONTRACT ITEMS IN GEORGIA

Item	Unit	Average Unit Prices 1940	Average Unit Prices 1946	Increase over 1940 (percent)
Common and borrow excav. (roadway)	cu. yd.	$0.23	$0.34	48
Unclassified excav. and borrow	cu. yd.	0.26	0.36	38
Local material base (Top soil, sand-clay, pebble-soil)	cu. yd.	0.35	0.55	57
Double bituminous surface treatment (Intermediate type paving)	sq. yd.	0.288	0.345	20
Bituminous concrete base (high type)	ton	6.00	6.07	1
Bituminous concrete surface (high type)	ton	6.00	6.65	11
Portland cement conc. pavement (8-in.)	sq. yd.	2.47	2.93	19
Class "A" concrete (bridges)	cu. yd.	22.61	43.57	93
Reinforcing steel (bridges)	lb.	.044	.069	57
Class "A" concrete (culverts)	cu. yd.	21.41	39.87	86
Reinforcing steel (culverts)	lb.	0.05	0.075	50

the costs of highway construction in Georgia was the critical shortage of heavy road building machinery and equipment. Parts were difficult to obtain and this often meant idle equipment until the needed repairs could be made.

Some contractors who could not secure needed equipment were forced to sublet large parts of their contracts to those who had such equipment available. Ordinarily, Georgia does not permit a prime contractor to sublet more than 20 percent of his contract, but due to equipment shortages, this had to be waived and a few contracts were sublet up to 50 percent of the total work.

Progress on construction also was slowed down in some instances due to shortages of steel and cement. The fact that a project had to close down while awaiting delivery of material tended to decrease working efficiency and added to the total cost of the project. We expect that deliveries of construction materials in 1947 will be more assured and that the rate of progress on the total state highway program will be increased.

Bridge workers were scarce

In bridge construction the primary factor in higher costs was due to increases in prices of materials. However, labor costs also were higher and the delay in delivery of materials was reflected in lower efficiency of working crews.

Because many of the skilled workers were either engaged in war work or were taking extended vacations while seeking employment similar to their war work, there was a shortage of bridge builders. In many instances, less-skilled workers were upgraded to fill out crews.

These problems had to be viewed realistically and allowances made in estimating costs. Every assistance was given to the contractors by the department to assist them in lowering costs and speeding completion of projects.

Of the 135 federal-aid contracts advertised for bids by the Georgia State Highway Department during 1946 only 17 were rejected. Ten of these were readvertised later and awarded. For the entire program only seven bids were rejected and not awarded. These seven bids totaled $410,000 out of a total of about $26,000,000 of highway construction contracts awarded during 1946.

Typical costs per mile

Typical examples of construction costs for primary highways are illustrated by one in Lowndes County where an 8-in. plain cement-concrete pavement 22 ft. wide with a 42-ft. graded roadbed cost $63,800 a mile. Another project, in Pickens County, involving the construction of an 8-in. plain cement-concrete pavement 22 ft. wide with a 34-ft. graded roadbed, cost $56,200 per mile. In these two examples grading and drainage were large factors in the difference in costs.

Differences in the cost of secondary road construction were much the same as for the primary highways, with grading and drainage playing an important part. One such road in Bibb County, with an 8-in. compacted base of local materials, a 20-ft. double

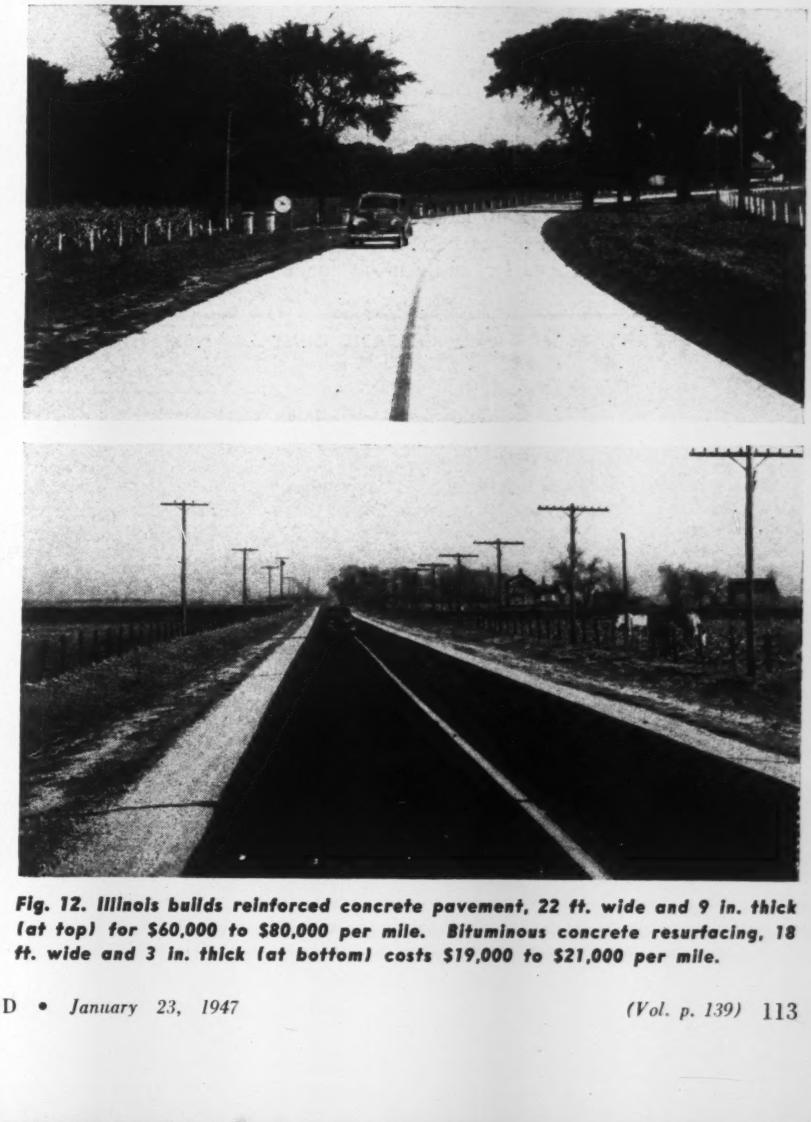


Fig. 12. Illinois builds reinforced concrete pavement, 22 ft. wide and 9 in. thick (at top) for $60,000 to $80,000 per mile. Bituminous concrete resurfacing, 18 ft. wide and 3 in. thick (at bottom) costs $19,000 to $21,000 per mile.

bituminous surface treatment, and a 32-ft. graded roadbed, cost $25,400 per mile. Another, in Talbot County, having the same type and width of graded roadbed, base and surface treatment, cost $16,100 per mile. All costs given above include grading and drainage.

The accompanying tabulation (Table IV) shows the increase in current costs for principal contract items as compared with 1940 prices. It will be noted that, for the most part, sharp price increases were the rule. Significantly, adjustment in material prices and increase in efficiency of labor will permit the construction of a greater mileage of Georgia highways, in the future.

Based on a survey which has just been completed, it will cost about $456,000,000 to bring the Georgia road system to the level desired by the highway department.

Contractor Profits on Highway Work Found To Be Normal in Oregon

R. H. Baldock
State Highway Engineer, Salem, Ore.

The current cost of highway construction in Oregon is about 50 percent higher than it was in 1940, except that on bridges and structures the cost has increased about 80 percent. From January to November, 1946, the cost of construction increased about 15 percent.

Two tabulations are included, showing comparative costs of highway construction in Oregon. One (Table V) shows a comparison of average bid prices received during 1940 and 1946, and a comparison of prices received during the first quarter and the fourth quarter of 1946. The other (Table VI) shows comparative costs per mile of constructing various types of highways during 1940 and 1946.

Analyzed construction costs

Cost analyses have been made on 22 road-construction contracts, representing an expenditure of $2,900,000. Sixteen contracts show an average profit of 15.4 percent, and six contracts, representing an expenditure of $507,000, show an average loss of 10.7 percent. The average profit for all 22 contracts was 12.1 percent, which is a normal profit and indicates that the bid prices are well in line with actual costs.

Increased wages likely

During the past year, there has been a decided trend toward higher prices due to difficulties experienced in procuring materials, equipment and supplies, and the necessity of finding, transporting and housing labor. Construction labor is still unsatisfied with its yearly wage, and a wage increase probably will be granted effective the early part of 1947. This will make it difficult to keep costs in 1947 from rising above those current in 1946.

Economies in careful planning

Careful planning, however, can reduce highway construction costs. Every device should be used to lengthen the working season. The war demonstrated that the black-top paving season can be lengthened by several months. Surfacing contractors will find it economical to crush and stockpile material during the winter months. The timing in the award of contracts should be carefully studied so that contractors can procure materials during the winter or to encourage winter work by fall lettings in the more favorable areas.

New equipment and new methods employed on several highway construction projects in Oregon last year increased production, saved labor and reduced costs.

Rejected 15 percent of bids

Oregon's postwar construction program has been underway about one year, since bids were received at the first letting on Oct. 29 and 30, 1945. During the year there were ten lettings, and bids were received on 107 grading, surfacing, oiling, paving and rock production contracts, and 24 bridge and structure contracts—a total of 131 contracts, amounting to $16,385,000. Ninety-one contracts, or 85 percent of the roadway contracts, were awarded, and 16 contracts, or 15 percent were rejected. Of the 24 bridge and structural contracts, 16 were awarded, and eight were rejected. The difficulty encountered in awarding bridge contracts was even more pronounced than these figures indicate, since only the most essential structures were advertised; all

TABLE V—COMPARATIVE BID PRICES FOR BASIC CONTRACT ITEMS IN OREGON

		Increase 1940–1946			Increase During 1946		
					Aver. Unit Prices		
		Av. Unit Prices			1st Quarter	4th Quarter	
Item	Unit	1940	1946	Increase (percent)	1946	1946	Increase (percent)
Common excavation.......	cu. yd.	$0.156	$0.212	36	$0.20	$0.23	15
Solid excavation...........	cu. yd.	0.52	0.74	42	0.70	0.81	16
Short overhaul............	yd. sta.	0.008	0.013	63	0.012	0.016	33
18-in. corr. iron pipe.......	lin. ft.	2.07	2.81	36	2.93	3.40	16
24-in. corr. iron pipe.......	lin. ft.	3.12	3.94	26	4.01	4.48	12
36-in. corr. iron pipe.......	lin. ft.	4.63	8.38	81	7.76	9.07	17
18-in. concrete pipe........	lin. ft.	1.87	2.70	44	2.78	2.20	..
24-in. concrete pipe........	lin. ft.	2.69	4.27	59	3.78	5.00	32
30-in. concrete pipe........	lin. ft.	4.19	5.07	21	5.00	6.00	20
Pitrun gravel topping......	cu. yd.	0.48	0.87	81	1.13	0.71	..
Crushed rock surface.......	cu. yd.	1.34	2.03	51	1.97	2.00	2
Crushed rock in stockpile...	cu. yd.	1.38	2.47	79	2.33	2.73	17
Truck haul..............	yd. mi.	0.08	0.138	73	0.15	0.13	..
Mineral aggregate in place..	cu. yd.	2.30	3.24	41	3.09	3.48	13
Asphalt in place..........	ton	21.50	32.91	53	31.29	36.70	17
P.C.C. pavement..........	sq. yd.	1.58	2.45	55	.....	.....	..
Asph. conc. pavement......	ton	4.47	5.81	30	4.90	5.97	22
Class "A" concrete........	cu. yd.	22.34	43.42	94	39.21	43.85	12
Treated lumber...........	M. ft.	95.79	190.20	99	.....	.....	..
Untreated lumber.........	M. ft.	46.34	165.48	257	109.16	175.00	60
Treated piling............	lin. ft.	0.78	1.33	71	1.08	1.50	39
Structural steel...........	lb.	0.075	0.132	76	0.13	0.14	8
Reinforcing steel..........	lb.	0.053	0.084	58	0.073	0.098	34

TABLE VI—COMPARATIVE COST PER MILE OF HIGHWAY CONSTRUCTION IN OREGON

Type of Construction	Per-Mile Costs 1940	Per-Mile Costs 1946	Increase (percent)
(a) Primary Highway — P.C.C. Pavement, 8-in. thick, 24-ft. wide, 10-ft. shoulders:			
Clearing, drainage and grading	$29,942	$44,258	47.8
Surfacing, paving and sholuders	30,920	45,068	45.8
Total	60,862	89,326	46.8
(b) Primary Highway — Asph. Conc. Pavement, 5-in. thick, 24-ft. wide, 10-ft. shoulders:			
Clearing, drainage and grading	25,855	37,848	46.3
Surfacing, paving and shoulders	27,619	39,025	41.3
Total	53,474	76,873	43.8
(c) Primary Highway — Bit. Mac. Wearing Surface, 3-in. thick, 22-ft. wide, 8-ft. shoulders:			
Clearing, drainage and grading	7,194	10,788	48.4
Surfacing, bit. mac. surface, and shoulders	17,427	24,500	40.6
Total	24,621	35,178	42.9
(d) Secondary Highway — Oil Mat Surfacing, 1¼-in. thick, 20-ft. wide, 3-ft. shoulders:			
Clearing, drainage and grading	10,228	16,032	56.8
Surfacing, oil mat surface and shoulders	11,440	16,430	43.6
Total	$21,668	$32,462	49.8

others being deferred for more favorable conditions.

The bid prices received on the first lettings averaged about 35 percent above 1940 prices; whereas the bids received on later lettings have increased to about 50 percent above 1940 prices on road contracts, and 80 percent on bridge and structural contracts. The engineer's estimate was 2.2 percent above the low bids received on all 131 contracts, and 5.2 percent above low bids received on the 107 contracts awarded.

Postwar construction costs probably have reached their high peak in Oregon. It is anticipated by the writer that 1947 prices may be slightly higher than present prices during the first part of the year, but that they will recede to below present prices during the latter part of 1947.

Freeways are Costly in California

G. T. McCoy
State Highway Engineer
California Division of Highways, Sacramento

The trend of highway construction costs in California during the past year has followed closely the pattern of national shortages of materials, equipment, and some classifications of labor. Just how some of the major contract items have increased in cost is shown in the accompanying tabulation (Table VIII), which covers the period from Feb. 27 to Nov. 14, 1946 and is based on 68 road and bridge construction projects with an aggregate cost of $25,184,000.

Prices and comparisons in this table have been broken down for two portions of the nine-month period, with a further breakdown of average increases between northern and southern California.

Prior to and during the early part of the war period, construction costs in the southern portion of the state were considerably lower than those in the north. Wages, rents, food and the general economy were subnormal to the rest of the state. However, during the last three years or so, particularly within the past 18 months, the southern level has risen to that of the north. This has created a condition whereby current cost increases over 1940 prices are noticeably more in the south; this is especially noticeable in bridge items.

The accompanying comparison of 1946 average total contract costs with 1940 prices (Table VII), divided between road and bridge contracts and between the north and south, provides additional information which is essential to any understanding of the situation in California.

It will be noted in Table VIII that the cost of roadway excavation has declined slightly since January 1946. This is attributed to greater availability of replacement equipment and to the release of a large number of competent operators from the armed forces.

In contrast to these conditions, work on structures or work requiring the processing of materials has risen in cost because of the uncertainties of material supplies and a definite lack of skilled personnel in the producing trades. These conditions are felt particularly in the field of concrete structures.

Freeways are costly

Highway development in California metropolitan areas, like those in other states, suffered from lack of construction during the war years. A large portion of postwar projects now under way in this state has been designed on the freeway principle to alleviate the serious traffic problems in the more densely populated sections.

Many of the structures included in

TABLE VII—COMPARISON OF CALIFORNIA'S CURRENT COSTS OF HIGHWAY CONSTRUCTION TO 1940 COSTS

	Percentage Increases over 1940 Costs		
	Roads	Bridges	All Projects
Northern California:			
Feb. 27 to June 30, 1946	40%	40%	40%
July 1 to Nov. 21, 1946	45	67	50
Entire period	43	53	45
Southern California:			
Feb. 27 to June 30, 1946	46	66	58
July 1 to Nov. 21, 1946	64	80	72
Entire period	57	73	65
Entire State:			
Feb. 27 to June 30, 1946	42	55	47
July 1 to Nov. 21, 1946	51	74	58
Entire period	47	65	53

TABLE VIII—COMPARATIVE COST OF HIGHWAY CONSTRUCTION IN CALIFORNIA FOR 1940 AND 1946

Period	Roadway excavation (per cu. yd.)	Imported borrow (per cu. yd.)	Class "B" P.C.C. pavement (per cu. yd.)	Asphalt concrete pavement (per ton)	Plant mix surfacing (per ton)	Structure concrete (per cu. yd.)	Reinforcing steel (per lb.)
Average Unit Contract Costs:							
Feb. 27 to June 30, 1946	$0.45	$0.87	$12.20	$4.83	$4.37	$39.84	$0.059
July 1 to Nov. 14, 1946	0.38	0.70	12.25	4.99	4.28	49.74	0.080
Entire period, Feb. 27–Nov. 14	0.41	0.75	10.94	4.92	4.30	45.32	0.069
*Increase over 1940 prices:							
Feb. 27 to June 30, 1946	18%	50%	33%	51%	43%	72%	34%
July 1 to Nov. 14, 1946	35	39	59	47	58	107	74
Entire period, Feb. 27–Nov. 14	27	43	43	48	52	92	53
Unit Contract Prices of Jan. 1, 1946	$0.43	$0.73	$8.67	$4.25	$3.43	$37.03	$0.058
Increase since Jan. 1946:							
Feb. 27 to June 30, 1946	7%	19%	18%	14%	27%	8%	2%
July 1 to Nov. 14, 1946	−10	−10	41	17	25	34	38
Entire period, Feb. 27–Nov. 14	−2	3	26	16	25	22	19
Feb. 27 to Nov. 14, 1946 (percent increase over 1940 prices)							
Northern California	29%	46%	37%	50%	52%	88%	41%
Southern California	23%	21%	56%	34%	52%	96%	66%

* Increased cost percentages were obtained from unit costs, adjusted on each project for differences in specifications or construction conditions.

this work involve close vertical clearance controls which have been met by use of the box girder type of concrete design. It is recognized that this type of construction is more costly per cubic yard of concrete because the thin sections and diaphragms require the best in forms with increased placing costs, all of which necessitates highly skilled labor.

Aesthetic considerations also influenced design of the many urban grade separations to the box girder type. The state expends considerable amounts in landscaping at these structures and the box girder lends itself to artistic design which fits in with the beautification of the surroundings.

In addition to higher wage rates, there are two elements of labor cost that result in higher unit costs. One is the upgrading of labor whereby an employer, in order to maintain an adequate crew of employees, works men at higher classifications than their skill or experience warrants. The other is the high percentage of overtime at time and one-half and double time rates. This overtime element is frequently a deciding factor in obtaining and keeping sufficient personnel.

A study made of labor costs on current projects shows that on road contracts about 37 percent of the contract price is paid out for direct labor, including social security payments and compensation insurance. About 41 percent goes to labor on the site for bridge jobs.

In any consideration of the current higher costs of highway construction, it also should be noted that a portion of the rise is due to other than increased cost of materials, equipment and labor. On the many projects located in metropolitan areas, the dense traffic, utility complications, and housing conditions present costly problems which were not common to most of the prewar construction.

Fig. 3. Costs were reduced, labor was saved, and the rate of construction was increased on several highway projects in Oregon during 1946 through the use of new equipment and improved methods of construction.

See little reduction in costs

As to future costs, there appears to be no reason for expecting any sharp decline in prices. At the present, we in California are obtaining good competition in bidding and our analyses indicate that contractors are working on about as close margins as conditions will permit.

Undoubtedly, moderate reduction will occur as material conditions stabilize, but it is thought that further reductions can come only through increased efficiency of operation. It is scarcely conceivable that there will be any early decrease in wage rates which are now pegged to a higher over-all economy.

Bids less than estimates

The first bids on the California state highway postwar construction program were opened on Nov. 28, 1945. Between that date and Dec. 1, 1946, bids were opened on 265 projects. The engineers' estimates of contract items on these projects totalled $64,128,200. The low bid prices amounted to a total of $62,404,800—a net "savings" of 2.69 percent.

Of the 265 low bids, 137 were under the estimates with a total savings of $4,430,100. These averaged 12.5 percent below the estimates. There were 128 bids that exceeded the estimates with a total overrun of $2,706,800. The overruns averaged 15.9 percent above the estimates.

On Dec. 1, 1946, 237 contracts had been awarded, the contract items of which totalled $59,180,900. Three contracts amounting to $257,900 in bid items were pending award on that date. Of the total bids received, all bids were rejected on 25 projects, the value of which amounted to $2,966,000. Several of these projects, rejected because of faulty low bids were, however, readvertised and subsequently awarded. On some, which were rejected as being too high, the jobs were revamped, readvertised and later awarded.

No lack of contractors

California has experienced no difficulty from lack of bidders. The proposals received on the 265 projects between Nov. 28, 1945 and Dec. 1, 1946 averaged five bids per job and in many instances the number was from ten to eighteen per project. Of all the jobs advertised for bids there were only seven for which no bids were received and in each of these cases there was some apparent reason for the lack of interest by contractors, such as isolated locations or a time of year when high water might be expected.

Shortage of materials, particularly steel, has been detrimental to advancement of the program. However, here in California the housing shortage has been our chief stumbling block.

Our postwar program includes considerable construction for freeway development in the Los Angeles and San Francisco Bay areas and, with the housing situation as it is, the state is reluctant to evict tenants from buildings on the right-of-way prior to clearing for construction. Had we been able to go forward with this phase of the program, the total contracts would have amounted to about ten million dollars more.

Material Shortages in Louisiana May Increase Highway Costs

N. E. Lant
Chief Engineer, Department of Highways,
Baton Rouge, La.

Highway construction in Louisiana continued on a substantial scale throughout the war years. Extensive Army maneuvers over wide areas of the state, erection of large war plants and military establishments, together with substantial increases in civilian traffic in and around certain metropolitan centers created a large volume of necessary highway construction work.

Cost records assembled during the war years enabled the state to anticipate, more or less accurately, the unit prices to be used in preparing estimates on postwar construction programs. Estimated costs for the 1946 program were based on increases in unit prices over 1940 prices of from 20 to 150 percent for major contract items. Bids received during 1946, with some few exceptions, have been within about 10 percent of our estimates. Comparative unit costs on our major contract items for the years 1940 and 1946 are shown in the accompanying tabulation (Table IX).

Several bids rejected

During 1946 the state rejected bids and readvertised projects involving about $1,000,000 worth of highway construction. Acceptable bids were received on all projects that were readvertised, but in some instances the estimates were revised before readvertisement to cover conditions peculiar to certain projects.

During last May and June the state advertised 53 projects on which no bids were offered. However, it was generally conceded that contractors were awaiting the outcome of labor legislation pending in the state legislature then in session.

Labor costs appear stable

In general, slowly rising costs are anticipated in Louisiana due to material shortages and uncertain deliveries. Labor costs, however, should not seriously affect future prices since wages in Louisiana have increased from 100 percent for skilled and semiskilled labor to 115 percent for unskilled labor. At the same time, administrative and supervisory costs have increased only about 50 percent. It is anticipated that, in general, labor will be available and no substantial increase in wages is expected.

The terrain of Louisiana is such that large differences in per-mile costs develop in different sections of the state. In the coastal section, for example, the cost per mile is extremely high when compared with the northern or hilly section. This is due chiefly to the expensive foundation work necessary.

Some of the primary concrete paved roads in the coastal section have cost in excess of $200,000 per mile. The costs of aggregate type bases and surfaces also are relatively high in the coastal area due to the scarcity of good local materials and to the poor distribution of local materials suitable for use.

A general average over the entire

TABLE IX—COMPARATIVE UNIT COSTS OF HIGHWAY CONSTRUCTION IN LOUISIANA

Item	Unit	1940 Unit Cost	Current Unit Cost	Increase over 1940 (percent)
Aggregate base course	cu. yd.	$3.20	$4.00	25
Aggregate surfacing	cu. yd.	2.90	3.60	24
P.C.C. pavement (8-in.)	sq. yd.	1.45	2.60	79
Triple surface treatment	sq. yd.	.30	0.40	33
Structural concrete	cu. yd.	22.00	50.00	127
Structural steel	lb.	0.08	0.15	88
Reinforcing steel	lb.	0.04	0.10	150
Earthwork (12-in.)	cu. yd.	0.22	0.50	127
Solid sodding (2-in.)	sq. yd.	0.20	0.50	150
Creosoted timber piling	lin. ft.	1.00	1.60	60
Reinf. conc. piling (14-in.)	lin. ft.	3.10	6.00	94
Creosoted timber	M. ft.	96.00	250.00	160
Untreated timber	M. ft.	101.00	215.00	113

state is about as follows: Portland-cement-concrete paved primary and secondary highways cost $103,000 and $60,000, respectively, per mile. Secondary highways, complete with a high type of treated surface, cost $31,000 and those involving grading and surfacing with stone or with some other aggregate cost about $21,000 per mile.

Virginia's Highway Costs Up 15 Percent Since January 1946

C. S. Mullen
Chief Engineer, Department of Highways
Richmond, Va.

The present trend of highway and bridge construction in this state is that Virginia expects to put underway within the next eight months a large construction program involving primary, secondary, urban, and railroad grade-crossing projects. It is felt that the construction industry will be in a position to obtain the needed materials, equipment and labor in larger quantities than heretofore, and that the postwar program will begin moving on a larger scale, and be well under way in 1947.

Labor scarce and expensive

Current highway costs in Virginia have indicated an upward trend due primarily to the lack of and high cost of labor, scarcity of materials particularly lumber, steel, and in some instances cement, as well as the difficulty of securing new equipment and repairs for the old.

As compared to 1940 costs, current bid prices are up approximately 65 percent, 15 percent of which has occurred since January, 1946. The costs of the most important basic contract items have been compiled (Table X) to show the extent of these increases.

Four-lane divided highways with high type surfacing such as reinforced concrete are costing about $160,000 per mile, which includes grading, drainage and surfacing. Intermediate types such as oiled-gravel surfacing cost approximately $20,000 per mile, and low-type surface-treated farm-to-market roads cost on an average of $10,000 per mile.

As of September, 1946, 72.8 percent of all projects advertised during 1946 had been awarded, which means that low bid prices received for the work were not more than ten percent above the engineers' estimate. Bids were rejected on 20.8 percent of the work, as being too high. No bids were received on 6.4 percent of the work advertised.

Generally, bids have been above the engineers' estimate, ranging from 100 percent above to 42 percent below in some erratic cases. Engineers' estimates have been increased approximately 60 percent above 1940 figures based on increases in labor costs in which is reflected the inefficiency of labor as well as labor rates. Also taken into considerations are the high material and equipment costs.

At present there is no acute shortage of contractors available for highway construction in Virginia. However, as the construction season advances, it is expected that a shortage of contractors will develop, especially among those bidding on small projects.

TABLE X—COMPARATIVE BID PRICES FOR BASIC CONTRACT ITEMS IN VIRGINIA

Item	Unit	Current Prices	Increase Since 1940 (percent)	Increase Since January 1946 (percent)
Unclassified excavation	cu. yd.	$0.45	65	15
Concrete (structural)	cu. yd.	50.00	95	25
Concrete paving	sq. yd.	3.00	58	12
Macadam	sq. yd.	1.70	52	10
Stabilization	cu. yd.	2.50	50	10
Structural steel	lb.	0.11	90	20
Reinforcing steel	lb.	0.08	75	15

Michigan's 1946 Highway Program Was Slow Getting Underway

Following a year of many difficulties which delayed the Michigan State Highway Department's $27,000,000 road and bridge program scheduled for 1946, the end of the year found the department in a good position to accelerate the work during 1947. Chief among the delaying troubles was a critical shortage of cement and steel.

Large lettings were held by the department in April and May of 1946, and again in October. Low bids offered, generally agreed with the engineers' estimates, requiring few rejections of bids for readvertising. In nearly all cases, however, when a project was readvertised, the award was made.

Contracts were awarded during

TABLE XI—COST OF 1946 HIGHWAY CONSTRUCTION PER MILE IN MICHIGAN

1946 Projects	No. of Projects	Total Length (miles)	Av. Cost per Mile: Engineers' Estimate	Av. Cost per Mile: Contract Price	Ratio of Contract Price to Eng. Estimate (percent)
Federal-aid roads grading and drainage struct.	13	47.2	$41,162	$39,408	−4.26
Oil aggregate surface	4	33.1	10,037	10,180	+1.42
Bituminous resurfacing	8	18.3	17,028	16,212	−4.79
Grading and drainage struct. and concrete paving	12	51.4	66,069	69,234	+4.79
County secondary roads: Grading and drainage struct. and gravel surfacing	25	103.9	10,910	11,824	+8.38

TABLE XII—COMPARATIVE BID PRICES FOR BASIC ITEMS IN MICHIGAN

		Quantities			Av. Unit Costs			Oct. 1946 costs:	
Item	Unit	1940	Early 1946	October 1946	1940	Early 1946	October 1946	Over 1940 Prices (percent)	Over Early 1946 Prices (percent)
Excavation	cu. yd.	3,332,700	1,564,300	1,747,200	$0.18	$0.204	$0.310	72.2	51.4
Class "A" concrete	cu. yd.	12,300	2,100	2,800	19.19	31.09	35.56	85.3	14.4
Reinforcing steel	lb.	942,800	119,700	213,700	0.06	0.07	0.082	36.7	17.1
8-in. concrete pavement	sq. yd.	1,500	213,400	220,100	2.10	2.245	2.55	21.4	13.6
9-in. concrete pavement	sq. yd.	None	60,700	389,800	......	2.24	2.803	....	25.1
10-in. concrete pavement	sq. yd.	11,700	None	110,200	1.91	......	3.00	57.1	....
Pavement reinforcement	sq. yd.	2,747,700	274,100	723,600	0.21	0.333	0.363	72.9	9.0
Sodding	sq. yd.	1,656,900	292,100	154,000	0.153	0.281	0.278	81.7	−1.0
Bituminous resurfacing	ton	4,300	None	12,400	7.95	......	8.18	2.9	....
Stabilized aggregate	ton	None	71,800	18,900	......	1.698	2.33	....	37.2

1946 for work that will cost $30,000,000 when completed. This work covers 32 miles of portland-cement concrete paving to be built on previously constructed grades; 97 miles of grading and drainage structures, mostly on locations to be paved this year; 103 miles of new grades and paving; 44 miles of grading and gravel surfacing; and 40 bridges and grade separations. A small portion of this construction was done in 1946. The remainder is scheduled for completion this year.

Heading the list of contract items for which unit prices have advanced the most since prewar days are excavation, and Class A concrete. As shown in Table XII, excavation has risen in cost 72 percent over 1940 average prices, and 51 percent during 1946. Class A Concrete now costs on an average of 85 percent more than in 1940.

Current average costs per mile of highway construction in Michigan are shown in Table XI, which also gives comparisons between the engineers' cost estimates on the work involved and contract prices.

North Dakota Rejected All Bids on Cement-Concrete Paving

M. P. Wynkoop
Chief Highway Engineer, Bismarck, N. D.

Comparison of unit bid prices on the $3,000,000 worth of highway construction on which contracts have been awarded in North Dakota since VJ-Day show a considerable increase over 1940 prices for this work. The percentage increase varies within wide limits on different types and items of construction. Examples of this variation in increases are shown in the following items:

Item	Current increase over 1940 prices (percent)
Road oil	10 to 32
Combined aggregate	70
Structural concrete	85
Stabilized base	40
Reinforcing steel	75
Structural steel	90
Roadway excavation	70
Reinforced concrete pipe	17 to 88

The items as listed are all bid in place, and the labor-material ratio very definitely shows in the foregoing percentages. For instance, the contract cost of items where labor has been a minor consideration, have increased proportionately less than those in which labor is a major consideration.

On most projects, contractors have been able to secure the minimum amount of labor necessary to staff their work. Seasonal fluctuations have occurred due to heavy demand when farm demand has been high. The quality of labor is somewhat lower than in 1940 and has resulted in higher labor costs and a general slowing down of man-hour production. In the skilled and semi-skilled classes it is difficult to obtain a supply of men capable of fine and detail finish work. In the higher skills, men have been working much overtime.

Construction bids have varied from 21 percent under the engineers' estimate to 42 percent over the estimate. Variation from low to high bidders has exceeded 30 percent on some projects. Twenty-three percent of all proposed construction has been rejected where bids have exceeded the upper limits set by the engineers' estimate. In dollar value, 22 percent of all bids have been rejected.

Contractors have shown a reluctance to bid on work where a large portion of the work extends into the next season because of the instability of wages and material costs, and a generally unsettled condition.

Present costs of building a 42-ft. grade with traffic surface gravel, 38-ft. stabilized base, and a 22-ft. intermediate type bituminous mat is approximately $35,000 per mile. Traffic is maintained on this type and all detours are eliminated. The above cost is proportioned in the following amounts: Earth grading, traffic surface gravel and incidental items, 50 percent: stabilized gravel base and bituminous surface, 50 percent.

All bids on concrete paving projects on North Dakota highways were rejected in 1946. The reason may be attributed to lack of transportation facilities and an extremely heavy demand for concrete materials.

Structural work has lagged far behind grading and surfacing work and in many cases it has held up the grading and surfacing items. Reinforcing steel and structural steel have been the main items delaying the work although in the latter part of the season cement shipments also delayed this work. If present supplies remain static, this condition will remain indefinitely.

In summarizing costs of bridge and highway construction, it appears that bridge construction costs have increased 70 percent where other highway construction items have increased about 60 percent. With an expanded highway construction program, greater availability of labor and increased supplies of materials, construction prices undoubtedly will remain at a fairly consistent level, with prospects for a slight decrease from our present costs.

Structural Steel Contract Prices Increased 49 percent over 1945

Thomas H. MacDonald
Commissioner, Public Roads Administration

Highway construction bid prices rose generally during 1946, according to cost data compiled by the Public Roads Administration. In the third quarter of 1946 the average bid price on concrete pavement (Table XIII) was $2.75 per sq. yd. as against $2.48 in 1945. For the same periods of comparison, reinforcing steel had risen to 7.6 cents from 6.2 cents per pound and structural steel jumped to 11.5 cents per pound from 7.7 cents—an increase of 49.9 percent. Bids on structural concrete advanced from $31.62 per cu. yd. in 1945 to $39.83 in the third quarter of 1946. Only in common excavation prices was there a decline—the 1946 third quarter average bid of 35 cents per cu. yd. being one cent lower than the 1945 figure.

The Public Roads Administration price index shows that composite-mile costs in the third quarter of 1946 (Fig. 4) were well above those in 1945. The moderate decline in excavation costs was more than offset by increased pavement costs. Principally, the over-all rise resulted from the great increase in the cost of structures, which rose far above the previous peak established in 1944.

By way of explanation, the price index of a composite mile of federal-aid highway construction shown in Fig. 4, is based on the average cost per mile during the years 1925 to 1929 as a base of 100. Quantities per mile of highway and base prices used in compiling this index are: 17,491 cu. yd. of common excavation at $0.35 per cu. yd.; 3,726 sq. yd. of concrete paving at $2.22; 16,000 lb. of reinforcing steel at $0.052; 4,325 lb. of structural steel at $0.067 and 68 cu. yd. of structural concrete at $22.15 per cu. yd.

TABLE XIII—COMPARATIVE UNIT CONTRACT PRICES ON FEDERAL-AID HIGHWAY CONSTRUCTION

(From data compiled by the Public Roads Administration)

Item	Unit	Av. Contract Bid Prices 1940	Av. Contract Bid Prices 1945	Av. Contract Bid Prices 1946 (3rd Quarter)	1946 (3rd Quarter) Increases Over 1940 (percent)	1946 (3rd Quarter) Increases Over 1945 (percent)
Common excavation...	cu. yd.	$0.21	$0.36	$0.35	66.7	−2.8
P.C.C. pavement......	sq. yd.	1.68	2.48	2.75	63.7	10.9
Reinforcing steel......	lb.	0.045	0.062	0.076	68.9	22.6
Structural steel........	lb.	0.063	0.077	0.115	82.5	49.4
Structural concrete....	cu. yd.	19.17	31.62	39.83	107.8	26.0

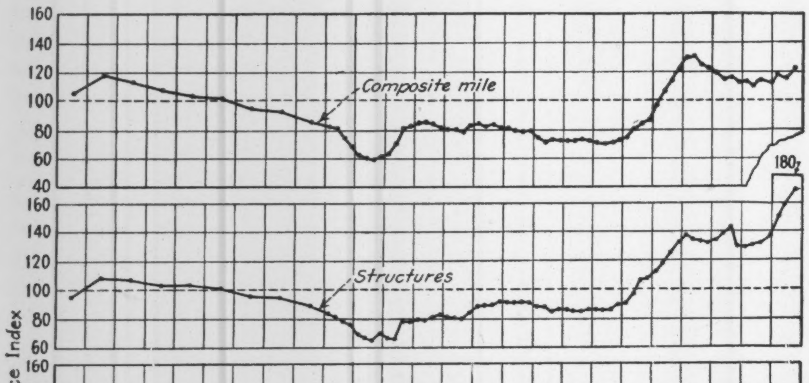


Fig. 4. Index of price trends on highway construction as compiled by the Public Roads Administration, using a base of 100 for average costs of 1925 to 1929.

Error in Pile Formula

An error was made in setting in type the hammer-size formula on vol. p. 870 of the Dec. 26, 1946, issue of *ENR* in an article by W. H. Rabe entitled "Dynamic Pile-Bearing Formula With Static Supplement". The correct formula should be:

$$F \text{ (or } WH) = \frac{N \times C \times R}{B\left[1 - J \times \dfrac{\frac{P}{2}}{W + \frac{P}{2}}\right]}$$

Reprints of this article with this formula correctly shown are being made and may be obtained by addressing the Editor, Engineering News-Record, 330 West 42nd St., New York 18, N. Y.

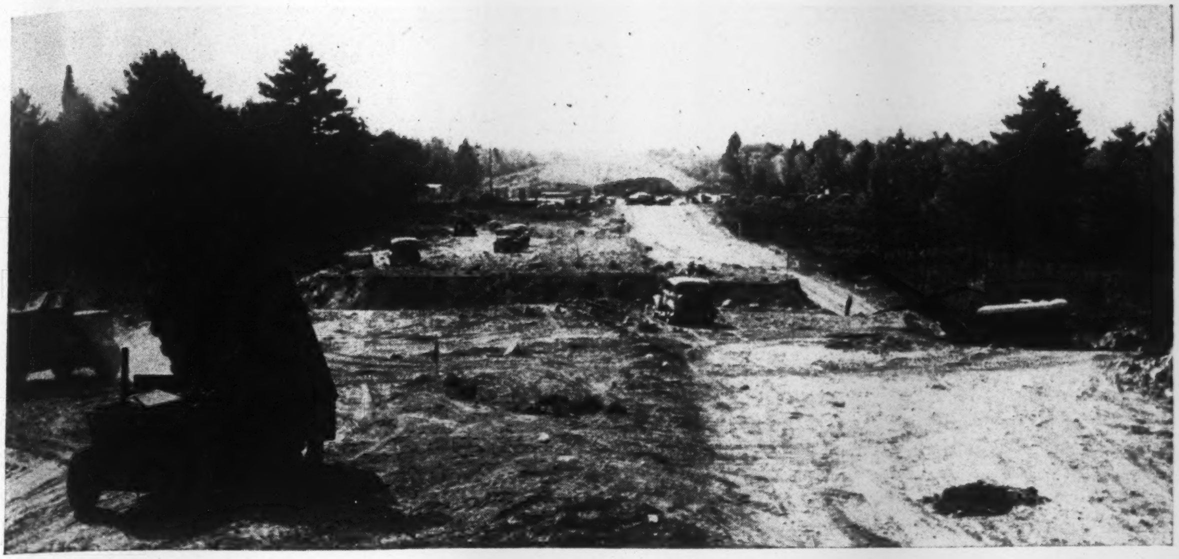


Fig. 1. Fills on Maine Turnpike are built of selected materials to insure their stability under severe winter conditions.

Work Begins on the Maine Turnpike

E. R. Needles
Howard, Needles, Tammen & Bergendoff,
Consulting Engineers, New York

Contents in Brief*—Construction of a toll highway to relieve traffic congestion on the principal highway providing access to the coast cities of Maine and to the state's vacation resorts was begun in 1945 in the expectation of having the first 44-mile section ready for use in the fall of 1947. Because of the rugged climate, special attention is being given to the subgrade to eliminate damage due to frost action, and the pavement and shoulders are designed to facilitate keeping the highway free of ice and snow.*

LONG KNOWN as one of our older and more conventional states, where conservatism is inherent and radical changes from established precedents are not common, the state of Maine is now carrying forward the construction of a new 4-lane dual superhighway that takes front rank in modern highway conception, finance, design and execution. Undoubtedly this action by Maine has done a great deal to emphasize again the current trend toward expensive superhighway construction in critical areas and to meet critical conditions on the basis that "the user pays".

The Maine Turnpike is being built without federal aid, without any burden on the credit of the state, without any contribution by the state, and without the use of state gas-tax funds or other state funds. Funds for construction and all other costs are being provided solely through the sale of revenue bonds of the Maine Turnpike Authority, interest and principal for such bonds to be cared for by modest tolls to be paid by those motorists who actually use the turnpike. Support for the sale of these bonds was provided through a report on prospective traffic and earnings by a nationally recognized firm of traffic engineers; by a report on engineering and construction to show the character of the project and the service it will render, prepared by the consulting engineers of the authority; and by a trust indenture or agreement between the authority and the bond trustee, representing the bond buyers, by which the authority obligated itself to construct, operate and maintain the turnpike not only for the benefit of the travelling public but for the benefit of the bond holders until the bonded indebtedness shall be discharged.

The sale of $15,000,000 revenue bonds of the Maine Turnpike Authority was concluded through a syndicate of investment bankers on Feb. 15, 1946. The interest rate was fixed at 2½ percent, beyond question the lowest rate on record for revenue bonds for a construction project. Only after the sale of these bonds did the authority have any funds of its own with which to conduct its operations.

A turnpike authority set up

The Maine Turnpike Authority was created by an act of the state legislature approved April 17, 1941. This act authorized a toll turnpike to be

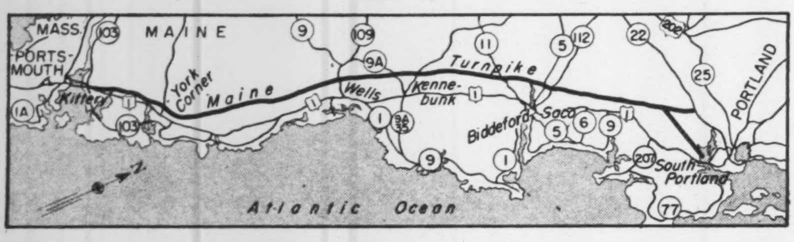


Fig. 2. The first section of the Maine Turnpike will provide a route parallel to the highway along the coast (U. S. Route 1) from the Massachusetts border to the approaches to Portland. Ultimately, it is planned to continue the turnpike across the state to the Canadian border at Ft. Kent.

constructed from Kittery, on the Maine-Massachusetts border, to Fort Kent, on the Canadian border, in such sections or integral units as would be self-liquidating. The first section selected and now under construction is the one from Kittery to Portland, a distance of about 44 miles. It is located westerly from and generally parallel to the existing U. S. Highway No. 1 which passes through the towns and cities of York, Ogunquit, Wells, Kennebunk, Biddeford, Saco and South Portland. Traffic difficulties and congestion along this highway, and particularly in these cities, had long demanded relief, and the selection of this first section of the turnpike for construction was recognized as most logical.

Aside from preliminary surveys, traffic studies and engineering studies by the State Highway Department, nothing in the way of substantial progress could be accomplished with World War II under way. Such work as could be done was accomplished through funds loaned to the authority. The turnpike, therefore, was looked upon as a postwar project, to be undertaken promptly upon the conclusion of the war. In the late summer of 1945, investment bankers, bond counsel and consulting engineers were engaged. In the fall of 1945, further surveys and traffic studies were carried out, and in January, 1946, a preliminary engineering report and a revised traffic report for financing purposes were produced.

Two-year construction program

A rapid rate of construction was most important in order to reduce to a minimum the interest charges during the construction period and to produce revenue as soon as possible through toll collections. A two-year construction program was adopted, grading to be pushed during the first working season, with paving to be completed during the second working season. Bridges and similar structures were to be started during the first and completed during the second working season.

Upon the sale of bonds on Feb. 15, 1946, field and office operations started at once. Field headquarters were established in Kennebunk. Final surveys were started for engineering and for land acquisition. Geological surveys, soil surveys and borings, timber surveys and borrow-pit investigations were all started. Arrangements were made for prompt foundation borings and explorations. Every possible advance was made in preparing bidding plans and specifications for clearing, grubbing, grading and minor drainage structures, pending receipt of field data.

Following the method used so often and so successfully in war construction, the necessary dead-line dates for progress were determined somewhat in reverse. It was recognized that use of the full working season would require the grading contractors to be actually at work during the latter part of May, 1946. Thus rights-of-way for working purposes had to be acquired after February, 1946, and by May, 1946. The authority did not have an executive director, an office or a land-acquisition department until in March. In order to allow the grading contractors to start work during May, 1946, bids had to be received early in May. In order to bid intelligently, the contractors had to be furnished bidding plans and specifications not later than early in April, which was barely seven weeks after the sale of bonds. Bids on clearing, grubbing, grading and minor drainage structures were received on May 2, 1946, contracts awarded the same day, and actual work on the ground was under way by May 15.

Bids made on unit-price basis

Careful planning and very intensive work were of course necessary in order to get construction started at such an early date. In addition, the bidding was arranged to avoid all unnecessary gamble on the part of the bidders, so far as possible. An escalator clause was inserted to provide that the authority would absorb any increase in the published base price of steel as allowed by the federal government after the date of the bidding and before shipment from the mill.

All bids were on a unit price basis, units being selected to represent all classes of work anticipated. The bidders were advised that variations from the bid quantities were to be anticipated, so that there could be adjustments made in lines and grades and similar items as the work unfolded. Each bidder named his own price for overhaul of embankment quantities. Borrow pits had to be approved as to quality, location and costs by the engineers; so the bidders

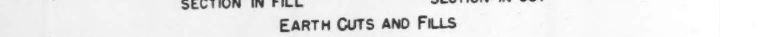


Fig. 3. Typical grading sections for the Maine Turnpike. The permeable material shown is to consist principally of granular material not over 10 percent of which will pass a 200 mesh sieve.

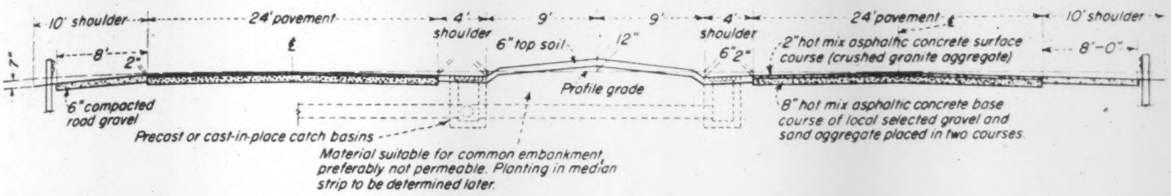

10' shoulder
24' pavement
4' shoulder
9'
9'
4' shoulder
24' pavement
10' shoulder
8'
2"
℄
6" top soil
12"
6" 2"
2" hot mix asphaltic concrete surface course (crushed granite aggregate)
8'-0"
Profile grade
6" compacted road gravel
Precast or cast-in-place catch basins
Material suitable for common embankment, preferably not permeable. Planting in median strip to be determined later.
8" hot mix asphaltic concrete base course of local selected gravel and sand aggregate placed in two courses

Fig. 4. Provision for winter maintenance was an important consideration in designing the pavement cross-sections. Ample storage space for snow is provided and catch basins are located where they will not be blocked easily by accumulations of ice and snow plowed from the roadways.

were advised that all costs due to rentals, royalties or purchase relative to borrow pits would be assumed by the authority. Considering the times, very satisfactory competitive bidding was attained, and all work has been awarded to excellent and experienced contractors.

For purposes of bidding, the 44 miles of grading were divided into four 11-mile sections. As a result of the bidding, two contractors each received two 11-mile sections. On Aug. 1, 1946, bids on 40 bridges and grade separations were received, divided into nine groups. As a result, one contractor was awarded seven groups, consisting of 38 structures, and another contractor was awarded two groups, consisting of two river bridges. On Nov. 26, 1946, bids on all paving were received, the work being divided into two sections of about 22 miles each. As a result, both sections, or all of the paving, have been awarded to one contractor, who now has the winter and early spring months available for planning, assembly of equipment and arranging for materials so that the entire working season of 1947 will be utilized for full-scale paving operations.

An unusually favorable autumn followed a very wet and unseasonable August. Thus, full activity on construction was maintained until the latter part of December, 1946, and utmost advantage was taken of the 1946 working season. At the end of 1946 the various construction operations are so well advanced that paving in 1947 should proceed without undue hindrance and the turnpike should be opened to traffic according to the original schedule on Nov. 1, 1947.

As of December, 1946, real-estate acquisition is virtually complete. Clearing, grubbing and stripping are substantially done. Grading is under way throughout the length of the turnpike, with most of the heavy work accomplished, about 20 miles now substantially ready for paving, and additional mileage to be available for paving late in the spring. Eighteen bridges and grade separations have been started, many substructures being well advanced. During the winter months of January and February, 1947, the principal work will be confined to river bridge foundations and to drilling and shooting such rock work as remains.

Costs run high

Construction costs on the Maine Turnpike have followed the general pattern of the postwar period to date. On the whole, very good competitive bidding has produced prices that are very high according to prewar standards but which appear fair and reasonable by all current comparable standards. Prices on grading and paving are considered quite reasonable, as might be expected where so much is contributed by heavy equipment, local materials and modest labor requirements. The bridge costs are very high, specifically because of labor and material conditions that create the current excessive housing and industrial-building costs. As of December, 1945, cost estimates for the turnpike were prepared with prices which averaged about 35 percent in excess of prewar prices. There appeared to be no definite reason to expect and certainly no reason to know that a steady increase in construction costs would develop throughout practically the entire year of 1946.

Actual bidding on the grading in May, 1946, showed costs about 15 percent in excess of the December, 1945, estimates, but within the contingency allowance for the total project. When the bids on bridges were opened in August, contract costs were established at some 50 percent in excess of the December, 1945, estimates. It appeared almost certain that this rate of increase would not follow on the paving, and some satisfaction was attained in receiving paving bids in November, 1946, that produced costs approximately 5 percent in excess of the December, 1945, estimates.

Altogether, the full construction cost of the Maine Turnpike, about $15,000,000, will be approximately 20 percent in excess of the cost estimate prepared in December, 1945. Normally, this excess cost over estimates would be very disconcerting, to say the least. However, in view of the great difficulties and uncertainties that prevailed in the construction field in 1946, and in view of the general disruption or complete stoppage of so many major postwar highway construction projects during this period, it is something of a major accomplishment that the work has progressed on schedule and that all major contracts are in the hands of competent, experienced contractors who give every evidence of getting the project completed by Nov. 1, 1947. Except for the bridge work, the competitive bidding was unusually broad and close, and by all current standards the contract prices must be considered fair and reasonable.

Provision made for changes

Because of the very limited time and the high speed operations which accompanied the start of actual construction on the turnpike, final decisions on numerous points were to be reached only after the work was started. Flexible unit-price contracts contemplated this procedure. Final location surveys made no material changes in the general alignment developed by the State Highway Department in earlier years. Grade changes were made in numerous instances as the work progressed to minimize rock work, improve drainage and subgrade conditions and to obtain larger yardages of particularly favorable embankment materials. In a few instances, test piles to supplement the borings prompted the selection of long steel piles in place of cast-in-place piles. In other cases, timber piles were substituted for steel piles to obtain quicker delivery and an earlier start on certain structures. Additional grade separations at county and farmroads were adopted. Improved entrance and exit arrangements were adopted at the Kittery and South Portland connections. Intermediate interchanges for entrance and exit purposes were finally established at Wells, Biddeford and Saco.

In addition to very high construction costs, real estate costs proved to be much in excess of the original estimate. Instead of lowering the design standards to secure savings in the construction of supplementary facilities such as shoulder paving, it was decided to complete the entire project for the attainment of minimum maintenance costs, satisfactory appearance and safety for the motorist.

Latest design standards used

In setting up the design standards for the Maine Turnpike, it was agreed that most modern design and construction should be attained. During the preliminary stage from September, 1945, to March, 1946, comparable superhighways were studied and many inspected. Design specifications from a great number of the different state highway departments were analyzed, compared and judged for applicable standards. It was decided that specific and complete contract documents, including specifications, should be written for each major contract to deal with the specific problems and conditions of the Maine Turnpike. In general, all construction was to conform to the design standards for the National System of Interstate Highways adopted by the American Association of State Highway Officials Aug. 1, 1945.

The original conceptions for this turnpike contemplated the utmost in safety and satisfaction for the motorist, good appearance, and full economy in construction and maintenance. Good alignment, flat curves and easy grades with full sight distance were fundamental. Fullest consideration was to be given to heavy snow and deep frost. Embankment construction was to be favored over cuts. Rock work was to be minimized. The embankments were to be thoroughly compacted of best available materials, and a highest quality pavement was to be constructed on a frost-free subgrade of granular materials.

The above general design standards have been followed closely. The maximum curvature is one degree without superelevation. The maximum gradient is not over 4 percent. The sight distance is 525 ft. from a position 4.5 ft. above the roadway to an object 4 in. high on the roadway surface. Embankment areas have been stripped of objectionable materials and all embankments have been compacted to 95 percent of maximum density at optimum moisture content as determined by laboratory tests. The frost-free subgrade of granular materials varies from about 2 to 4 ft. in thickness, depending on conditions to be met, suitable material for this subgrade being that which does not contain in excess of 10 percent of fines passing a 200 mesh screen.

This dual highway will have two lanes, 24-ft. wide, in each direction, separated by a median strip 26 ft. in width. The width of the median strip is constant throughout the length of the turnpike, requiring separate bridges for each two-lane highway over such streams as the York and Saco rivers. The central portion of the median strip is elevated above the roadway pavements, with drainage of each 24-ft. roadway from its center to its outer edges in order to minimize icing. Thus a series of roadway drains will be provided along each side of each median strip. Consideration was given to a depressed median strip with a single line of drains along the center thereof, but adequate snow removal under such conditions did not appear practicable.

Each 24-ft. roadway will have a 4-ft. paved shoulder on the side along the median strip. Along the outer sides will be 8-ft. paved shoulders for parking disabled vehicles. Both shoulders will permit fullest use of the full roadway widths and will greatly facilitate snow removal and reduce icing. These shoulders will be constructed of compacted road gravel, given an asphaltic surface treatment, and covered with white stone chips rolled into place.

Paved with asphalt

The turnpike pavement will be machine spread asphaltic concrete with an overall thickness of 8 in. The base course will be hot mixed, using local gravel aggregate, 6 in. in thickness and compacted in two 3-in. layers. The wearing surface will be 2 in. in thickness, hot mixed, and using a hard crushed granite aggregate. The asphaltic concrete pavement was selected by the authority and the highway commission because of adaptability to snow and ice conditions, economy, freedom from roadway joints and other reasons of local import. Roadway visibility or delineation will be emphasized by center striping with reflective material, by the white-stone surfaced shoulders, and by free use of reflector buttons on marker posts.

The Maine Turnpike Authority has direct and complete charge of turnpike operations, with approval of the State Highway Commission to be given on location, design, construction contracts and other formal matters. The two bodies have cooperated very closely, with Stillman E. Woodman, chairman of the highway commission, serving also as a member of the authority and Lucius D. Barrows, chief engineer of the highway commission, serving as secretary-treasurer of the authority. Joseph T. Sayward is chairman of the authority, with Paul C. Thurston, Charles W. Diggery and Boyd Harrington as members. William B. Getchell, Jr. is executive director of the authority. The traffic report on the turnpike was prepared by Coverdale and Colpitts. Engineers for the authority on designs, plans and supervision of construction are Howard, Needles, Tammen & Bergendoff. L. D. Brown is project engineer, situated at Kennebunk. Hamilton Gray is consultant on soils, materials and foundations.

The Lane Construction Corp. is the contractor on about 22 miles of grading and 43 bridges and grade separation structures. Ellis C. Snodgrass is the contractor on the York and Saco River bridges. The Savin Construction Corp. is the contractor on about 22 miles of grading. B. Perini & Sons is the contractor on all

Better Expansion Joints in Bridge Floors

Nathan W. Morgan
Principal Highway Bridge Engineer
Public Roads Administration, Washington, D. C.

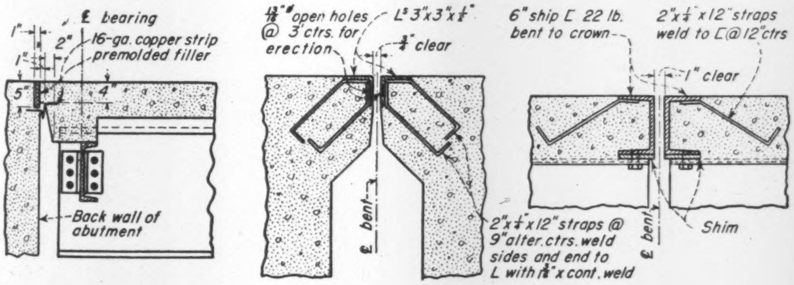
Contents in Brief*—Not only must expansion joints in bridge floors be designed to permit adequate movement, but they must be so constructed that their parts will not bind, warp or loosen under the constant hammering of heavy traffic. The joints must be properly drained, so designed as not to clog with ice or dirt, and with the openings in the floor sufficiently limited in size to avoid a traffic hazard. To meet all these conditions care must be exercised in selecting the type of joint and in determining a method for anchoring its parts in place.*

A RECENT STUDY of expansion joints in bridge floors by the bridge committee of the American Association of State Highway Officials reveals that state highway department design engineers are giving increasing attention to this important detail. The study further reveals that a logical design procedure is now being followed in order to obtain improved and satisfactory joints.

The correct design of expansion joints is an important factor in obtaining lower maintenance costs and increased safety. The greater the temperature variation and the length of structure involved, the more important well designed expansion joints become. With those structures where movement of the substructure is possible, the design of the joints takes on an added importance.

For a temperature change of 100 deg. F., the change in length for a steel or concrete bridge totals about $\frac{3}{4}$ in. per 100 ft. in length. However, standards of the AASHO specify that provision be made for a movement of $1\frac{1}{4}$ in. per 100 ft. per 100 deg. of temperature range, as compared with 1 in. per 100 ft. specified for railroad bridges by the American Railway Engineering Association. Provision is made for temperature movement of the structure at all supports excepting those that are to be fixed to the substructure for stability.

Movement of the bridge superstructure may also be caused by settlement or movement of the substructure. The possibility of vertical settlement as well as horizontal movement should be given consideration, especially at end supports where approach fills are made. In fact, the expectation of movement of the spans because of settlements in the foundations is probably as important as the matter of changes in temperature. Unfortunately, too often this factor is overlooked.


℄ bearing
1"
2"
16-ga. copper strip
premolded filler
1"
5"
4"
Back wall of abutment
$\frac{13}{16}$" open holes @ 3' ctrs. for erection
L^s 3"x3"x$\frac{1}{2}$"
$\frac{3}{4}$" clear
℄ bent
2"x$\frac{1}{4}$"x12" straps @ 9" alter. ctrs. weld sides and end to L with $\frac{3}{16}$"x cont. weld
6" ship ⊏ 22 lb. bent to crown
2"x$\frac{1}{4}$"x12" straps weld to ⊏ @ 12" ctrs
1" clear
Shim
℄ bent

JOINT A JOINT B JOINT C

Fig. 1. If a maximum movement of less than 1 in. is expected, an unarmored joint of design at left may be used, care being required during construction to protect the copper flashing. For movements up to 2 in. armored open joints of types B and C are satisfactory, type B having been designed for a reinforced concrete deck girder and type C for I-beam spans.

Modern bridge specifications further require that provision be made for movement of spans resulting from live load. This provision likewise affects the design of the floor expansion joints, particularly in long spans. Accuracy of shop fabrication and field measurements must also be given consideration. Further, it is advisable to provide for a reasonable amount of movement in excess of that actually calculated for temperature, for both the fully contracted and fully expanded positions. The judgment of the designing engineer must be relied upon to determine these allowances.

Once the location of the expansion joints has been selected, movement must be provided for the entire cross-section of the superstructure, that is, the joints must extend through the roadway, sidewalks, curbs, railings and supporting superstructure. However, this article will give attention specifically to the floor expansion joints, which are the most difficult to design.

Elements of good design

The floor joint must be provided with sufficient horizontal clearance between the moving parts to avoid the danger of interference, binding and freezing. Moreover, expansion devices should be so designed that parts will not extend above the roadway surface and thus become a danger to traffic. The collection of dirt, water and ice at the joint must also be prevented. At the same time, the size of the openings in the floor must be restricted so that they do not become a hazard for the feet of pedestrians and animals, or injurious to vehicle tires.

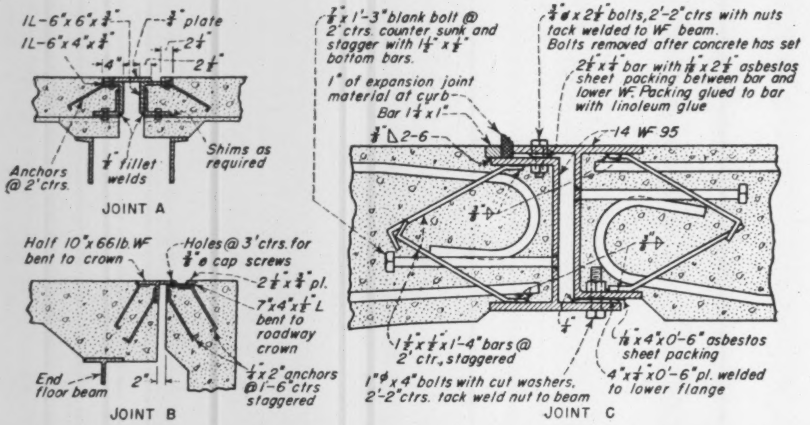

1L-6"x6"x3/4"
1L-6"x4"x3/4"
3/8" plate
4"
2 1/4"
2 1/4"
Anchors @ 2' ctrs.
1/4" fillet welds
Shims as required
JOINT A
Half 10"x66lb. WF bent to crown
Holes @ 3' ctrs. for 3/8" ø cap screws
2 1/2"x3/4" pl.
7"x4"x1/2" L bent to roadway crown
1/4"x2" anchors @ 1'-6" ctrs staggered
End floor beam
2"
JOINT B
7/8"x1'-3" blank bolt @ 2' ctrs. counter sunk and stagger with 1 1/2"x1/2" bottom bars.
1" of expansion joint material at curb
Bar 1 1/4"x1"
3/8" ◺ 2-6
3/4"ø x 2 1/2" bolts, 2'-2" ctrs with nuts tack welded to WF beam. Bolts removed after concrete has set
2 1/2"x1/4" bar with 1/16"x2 1/2" asbestos sheet packing between bar and lower WF. Packing glued to bar with linoleum glue
14 WF 95
3/8"
3/8"
1/4"
1 1/2"x1/2"x1'-4" bars @ 2' ctr., staggered
1"ϕ x 4" bolts with cut washers, 2'-2" ctrs. tack weld nut to beam
1/16"x4"x0'-6" asbestos sheet packing
4"x1/4"x0'-6" pl. welded to lower flange
JOINT C

Fig. 2. All three of the armored joints illustrated above have proved satisfactory where movements up to about 6 in. are to be accommodated. Use of welding in assembling Joint A permits a maximum amount of clearance. Construction of Joint B was simplified by use of wide flange sections in lieu of plates and angles. Joint C was used to provide movement between the end of concrete slabs.

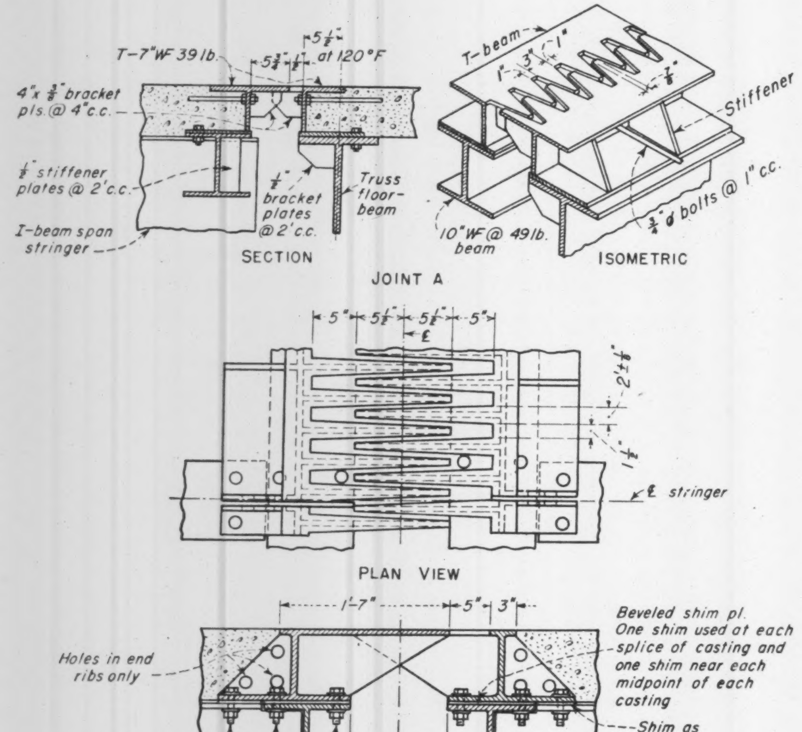

T-7" WF 39 lb.
5 3/4"
1/2"
5 1/2" at 120°F
4"x3/8" bracket pls. @ 4" c.c.
1/2" stiffener plates @ 2' c.c.
1/2" bracket plates @ 2' c.c.
Truss floor-beam
I-beam span stringer
SECTION
T-beam
1"
3"
1"
7/8"
Stiffener
3/4" ø bolts @ 1" c.c.
10" WF @ 49 lb. beam
ISOMETRIC
JOINT A
5"
5 1/2"
5 1/2"
5"
℄
2'±1/8"
1 1/2"
℄ stringer
PLAN VIEW
1'-7"
5"
3"
Holes in end ribs only
Beveled shim pl. One shim used at each splice of casting and one shim near each midpoint of each casting
Shim as required
3/4" ø bolts
11"
SECTION THROUGH JOINT
JOINT B

Fig. 3. For movement of over 6 in. the opening of the joint may be spanned by sturdy interlacing fingers cut from thick plates, by burning from halves of wide flange beams (Joint A), or built from special steel castings (Joint B).

The ideal floor expansion device provides a safe passage for the roadway traffic, smoothly and without noise or unnecessary impact. The parts and connections subject to the direct shock of traffic should be of heavy material connected by large rivets, lock bolts or welding. Lightweight parts tend to bend under the constant pounding of traffic and inadequate connections work loose, causing the joints to become noisy.

Better service has been attained when the principal expansion joint members are directly connected to members forming the floor system of the bridge. Fastening the expansion device directly to the steel floor members also assures ease and accuracy of positioning and maintenance of the joint. Where this method is impracticable, the joint members should be thoroughly anchored to the concrete slab and the end cross beams. The exposed parts of the expansion device must be of corrosion-resisting material, such as copper-bearing steel or steel castings. Finally, large joints subject to drainage water from the roadway must be provided with a drainage collecting system below the joint.

Such then are the overall requirements for good expansion joints. The selection of joints to meet these requirements will now be discussed.

Design of narrow joints

In the case of narrow joints with a small amount of movement, it is generally accepted that the opening should not exceed a maximum of 1 in. for an unarmored joint and 2 in. for the uncovered armored joint. A satisfactory type of unarmored narrow joint, such as would be satisfactory at the end of a beam span, is illustrated in Fig. 1A. The 1-in. joint between the end of the bridge slab and the backwall of the abutment is either left open or contains a filler capable of being compressed to 50 percent of its original thickness.

Various kinds of filler, including premolded and poured, are used for both the armored and unarmored narrow joints. The preformed fillers include bituminous material, bituminous fiber cork, self-expanding cork, sponge rubber, cork rubber, and a mixed asphalt and mineral. The poured fillers include rubber and asphalt. In all cases care must be exercised to prevent the loss of the filler.

The loss or displacement of the filler material in narrow joints is usually prevented either by nails through fiber fillers or by a supporting seat or similar device. Certain poured rubber fillers adhere sufficiently to the concrete faces of the joint so that no additional support is needed. To prevent the tearing of the copper flashing shown in Fig. 1A, the premolded joint filler is supported on the concrete and not upon the flashing. The purpose of the flashing is to prevent water from seeping through the joint, and care should be exercised during erection to protect the flashing. Dumbbell-shaped rubber water-stops are frequently used in lieu of flashing.

Two varieties of open armored joint for narrow openings are also illustrated by Figs. 1B and 1C. The principal advantage of the armored joint is the prevention of spalling of the exposed edges of the concrete slabs. For the joint shown by B of Fig. 1, 3 x 3 x ½-in. angles are used. Type C illustrates the use of 6-in. channels supported directly on the I-beams. The armor members are curved to fit the crown of the roadway slab, and shims are provided to facilitate proper adjustment during erection. Open holes are usually provided for bolting the steel members to the form-work on projects where the members cannot be anchored directly to the steel. Welded strap anchors are used to anchor the members rigidly to the concrete.

Design of wide joints

A continuous uncovered open joint of greater width than 2 in. is hazardous both as a source of impact from vehicles and as a possible danger to pedestrians and animals, and thus must be covered or broken down into a series of staggered openings. For openings having a maximum movement of about 6 in., a solid plate or its equivalent may be used to carry traffic across the openings. But experience has shown that heavy material and connections are essential in order to withstand the pounding of traffic and it is important that the sliding plate be at least ¾ to 1¼ in. thick because thin plates tend to cup and eventually to loosen.

Two expansion joints meeting these requirements are illustrated by Figs. 2A and 2B. To weld the vertical legs of the supporting angles in place as shown by Fig. 2A, is worth while, as this work gives additional clearance because of the lack of rivet heads. For the joint shown by Fig. 2B the edges exposed to the traffic have been beveled to eliminate the danger of cutting tires.

A somewhat different device designed to transfer loads as well as provide for movement between the contiguous ends of concrete frames or slabs is illustrated by Fig. 2C. The principal elements of this joint are two 12-in. 72-lb. wide-flange beams with the half of one flange burned off. The upper beam carries the end of a concrete slab, resting and sliding upon the lower beam which forms the end of a short cantilever arm. In using this type of joint, particular attention must be given to the anchorage of these elements into the concrete spans.

Best type for large openings

When it becomes necessary for expansion devices to span a larger opening or to provide for a greater movement than about 6 in., special devices usually consisting of interlacing fingers burned out from thick plates and shapes or those fabricated from special steel castings or rolled bars are used. Finger type devices for moderate movements and spans may have tapered or parallel fingers.

Two principal advantages of the tapered fingers are that maximum strength is provided at the base of the fingers and there is little tendency to freeze and bind during low temperatures. Also, the fingers lend themselves to strengthening by stiffeners or brackets placed underneath. However, it is important that tapered finger joints be so designed that the minimum clearance between fingers in the closed positions be not less than ¼ in. and that the joint does not produce too wide an opening when in the fully open position.

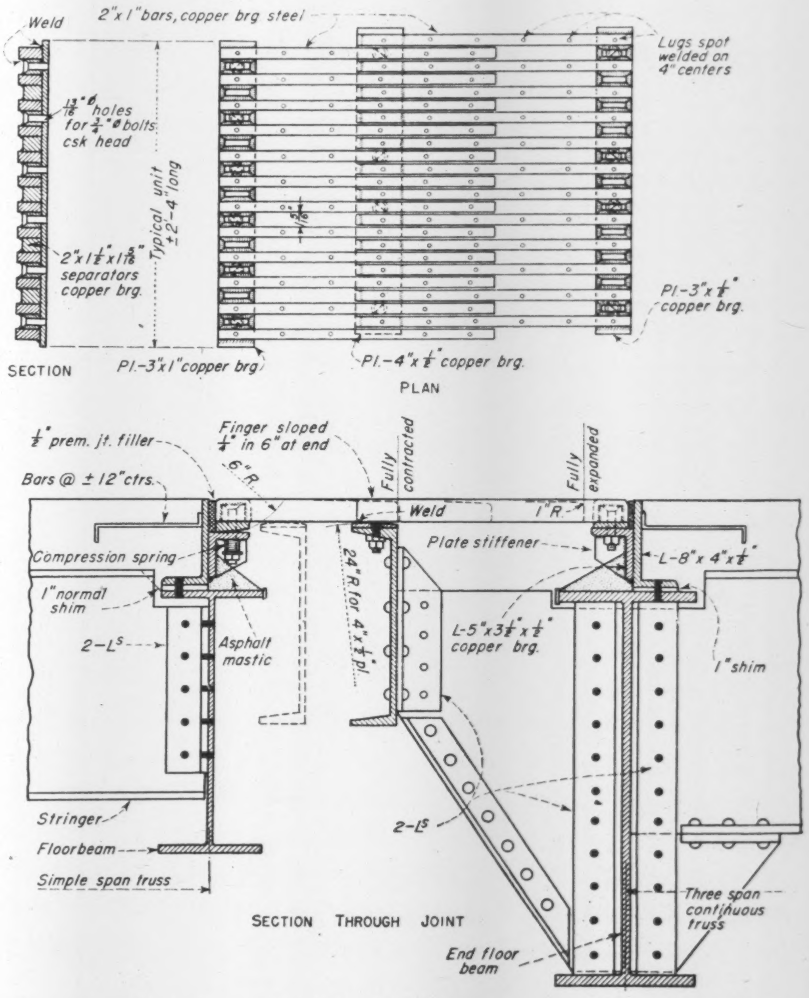

Weld
2"x 1" bars, copper brg steel
Lugs spot welded on 4" centers
13/16"Ø holes for ¾"Ø bolts csk head
Typical unit ±2'-4" long
5/16
2"x 1½"x 1 5/16" separators copper brg.
Pl.-3"x ½" copper brg.
SECTION
Pl.-3"x 1" copper brg
Pl.-4"x ½" copper brg.
PLAN
½" prem. jt. filler
Finger sloped ¼" in 6" at end
6" R.
Fully contracted
Fully expanded
Bars @ ± 12" ctrs.
Weld
1" R.
Plate stiffener
L-8"x 4"x ½"
Compression spring
1" normal shim
24" R. for 4"x ½" pl.
L-5"x 3½"x ½" copper brg.
2-L^s
Asphalt mastic
1" shim
Stringer
Floorbeam
Simple span truss
2-L^s
SECTION THROUGH JOINT
Three span continuous truss
End floor beam

Fig. 4. Where larger movements must be provided, the expansion joint is generally designed especially for the bridge being built. However, joints with parallel fingers are generally used with special care exercised to avoid a noisy joint.

Finger members may be fabricated from a thick plate with a cutting torch, by burning from halves of wide-flange beams or prepared as special steel castings (Fig. 3). It should be noted that these members are not only fastened directly to the steel floor system, but are also provided with additional anchorage into the concrete slabs. In using this type of expansion device the rivet heads on the roadway surface should be flattened.

Where larger amounts of movement are required, the type of expansion device shown in Fig. 4 is satisfactory. The ordinary finger joint of burned plates or shapes would not carry the traffic loads efficiently for this width of opening, and steel castings would become heavy and expensive. The design of Fig. 4 makes use of rectangular bars fastened at one end and resting on an intermediate support which provides a sliding and bearing surface.

Alternate bars do not slide but are welded to the intermediate support, assuring a fixed alignment for the sliding bars. The fixed ends of the sliding bars rest upon a rounded seat, with a spring attachment which provides automatic adjustment of the device when one of the supports moves vertically and helps prevent rattling. The bars are spaced with a ¼-in. horizontal clearance between sliding surfaces to help prevent freezing and binding due to accumulation of dirt. The upper surfaces are roughened by means of spot-weld lugs to provide greater resistance to the skidding of vehicles.

Numerous other good designs for expansion devices permitting large movements are being used and could be illustrated. But almost all of these joints are specially designed for a specific bridge and therefore will not be discussed in any further detail. However, it must be re-emphasized that the greater the movement to be accommodated the more important becomes the selection of materials and design of the joint to permit this movement.

Erection procedure important

During erection of the bridge particular attention must be given to the correct setting and adjustment of the main expansion bearings, to assure that their position is correct for the atmospheric temperature at that time and that the expansion joints will function properly. If the bridge is erected on a cold winter day, the expansion bearings should be set in a contracted position corresponding to this temperature. In order to facilitate this operation, it is important to indicate on the plans the amount of opening required for a given normal temperature.

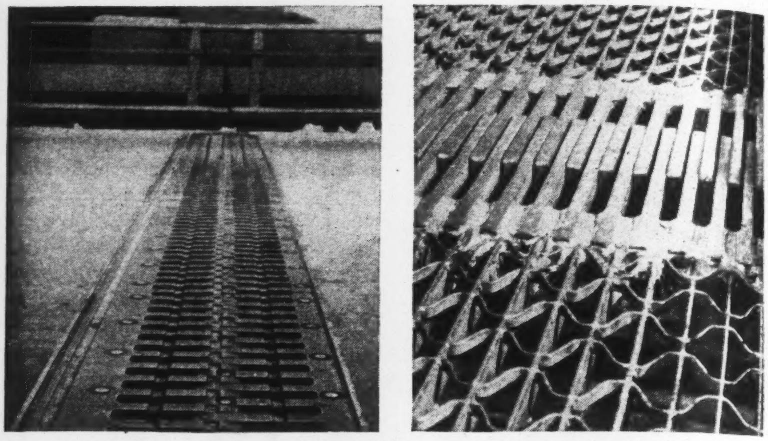


Fig. 5. Designers of the tied arch highway bridge across the Susquehanna River at Havre de Grace, Md., used the joint at left. On the crossing over Housatonic River in Connecticut, joint at right was installed.

To summarize, the work of bridge maintenance will be greatly reduced if care is exercised in the design and construction of the floor expansion joints so as to meet all the conditions under which they must function. Moreover, traffic will then not be subjected to the discomforts of the noise and irregularity of loose and faulty joints.

Standard Bridge Railing of Steel Tube

A railing of tubular steel has been developed by the California Division of Highways, Bridge Department, with a view to making it standard for use on bridges in that state. Thus far, however, this type of railing has been specified for only one or two bridges in the postwar period because of the steel material situation.

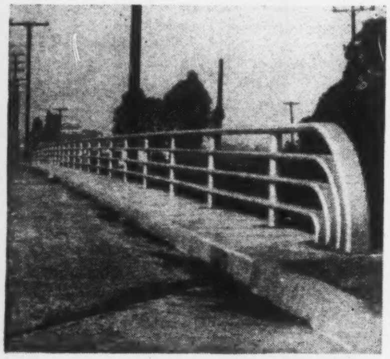


Fig. 1. Pleasing architectural lines are shown in this example of a standard bridge railing of steel tube recently developed in California.

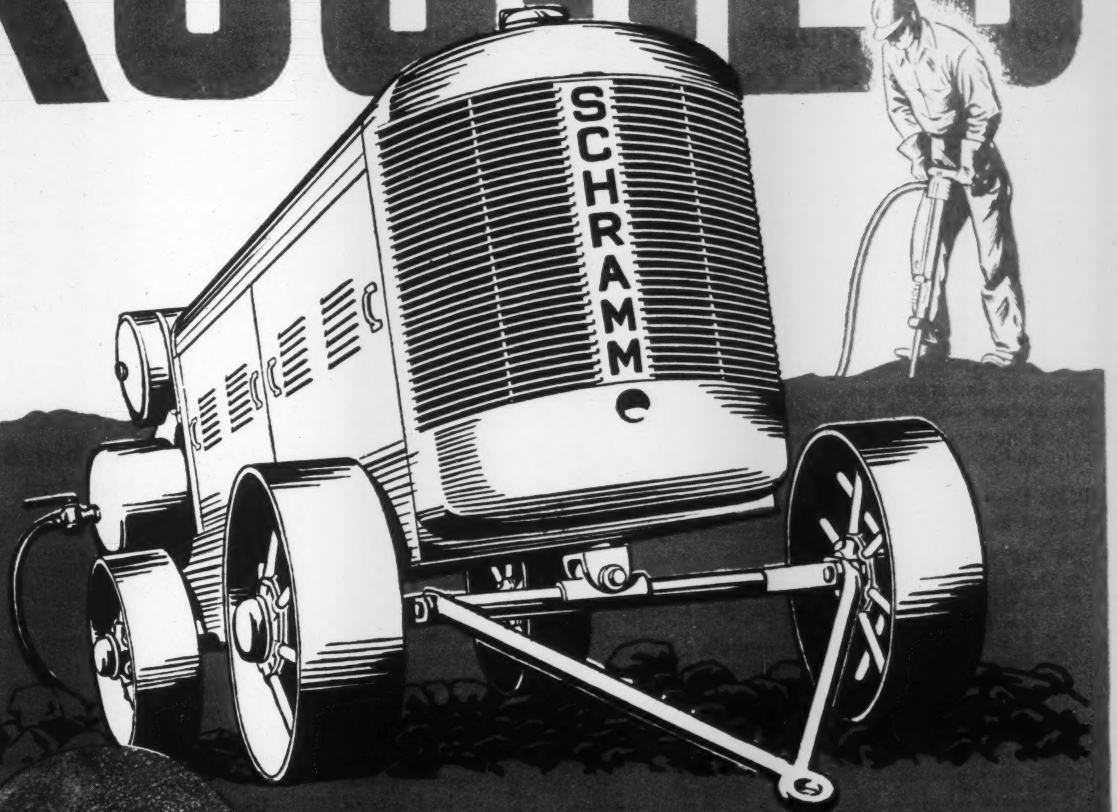
The railing is designed so that the broad oval-shaped members give an impression of strength, and so that full protection is given by the railing, with minimum effect on visibility.

The railing height can be specified as either 2-ft. 4-in. or 3-ft. Uprights are made of 3½-in., double extra strong pipe. Horizontal members are $\frac{3}{16}$-in. thick and have an oval cross-section. They can be made of steel plate rolled to shape and welded. An alternate method of making them is by rolling standard steel pipe to size. For example, the upper member, a little wider than the three lower members, can easily be made to size from 5-in. pipe.

Horizontal members are attached to the posts by means of sleeves which fit inside them. Thus, in case of accident, members may be easily removed for repair or replaced.

Development of this railing was under the direction of F. W. Panhorst, bridge engineer, California Department of Public Works, Division of Highways.

RUGGED



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UNIT PRICES BID BY CONTRACTORS

Highway Construction, Huntingdon Co., Pa.

OWNER: State Department of Highways, Harrisburg, Pennsylvania; T. C. Frame, Chief Engineer.

PROJECT: Construction of first section of U. S. 22 By-Pass at Huntingdon County, Pa. Work consists of highway construction and two substructures of a reinforced concrete bridge. Because of unavailability of steel, contract does not call for complete construction of bridge at this time.

CONDITIONS: Grading and drainage will vary from 49 ft. to 66 ft. in width. Approximately 907 lin. ft. of grading and drainage of railroad bed must be done. Native stone, type A, or crushed aggregate base course will be used with a bituminous surface course 20 ft. in width. Contract time is 140 days. Skilled labor rates are $1.10 per hour; semi-skilled, $.90 per hour; and common labor, $.70 per hour.

BIDS: Four bids were received October 18, 1946, ranging from the contract low of $510,138.09 to $759,982.78.

LIST OF BIDDERS:

1. Mauger-Smith Inc., Columbus, Ohio (contract)	$510,138.09
2. Central Pennsylvania Quarry, Stripping & Construction Co., Hazleton, Pa.	654,865.40
3. S. J. Groves & Sons Co., Johnstown, Pa.	722,012.80
4. B. Perini and Sons, Inc., Framington, Mass.	759,982.78

	Item	Quantity	Unit Prices (1)	(2)	(3)
1	Clearing and grubbing (state portion)	lump sum	$7,000.00	$10,000.00	$15,000.00
2	Class 1 excavation	339,917 cy	.62	1.06	1.10
3	Class 2 excavation	4,521 cy	3.00	6.25	4.00
5	Permanent barricade, type A	24 lf	20.00	6.00	4.00
6	Subgrade	5,829 cy	.30	.20	.30
8	Shoulders	2,385 lf	.30	.40	.40
13	Native stone, type A or crushed aggregate base crse. 8 in. in depth	5,829 sy	2.00	1.50	1.50
23	Plain cement concr. wearing surf. for bridge floors	412 sy	4.00	3.00	4.10
27	Bit. surf. crse. HC, HE, HSD or ID-2, 2½ in. in depth	5,638 sy	1.50	1.25	1.50
28	Class A concrete	617 cy	50.00	48.00	75.00
28a	Class AA concrete	9 cy	100.00	80.00	11.00
29	Class B concrete	1,796 cy	40.00	36.00	50.00
30	Plain steel bars	170,645 lb.	.07	.075	.12
32	Fabricated structural steel	3,805 lb	.20	.15	.16
35	Stone backfill for structures	180 cy	4.00	6.00	4.00
37	Concrete test piles (2 piles ea. 32 ft. long and 2 piles ea. 44 ft. long)	lump sum	1,900.00	3,000.00	3,000.00
38	Concrete piles—14 ft	28 lf	4.50	5.00	5.00
38a	Concrete piles—20 ft	40 lf	4.50	5.00	5.00
38b	Concrete piles—26 ft	130 lf	4.50	4.00	5.00
38c	Concrete piles—32 ft.	352 lf	3.50	4.00	5.00
38d	Concrete piles—38 ft	532 lf	3.50	4.00	5.00
38e	Concrete piles—44 ft.	616 lf	3.00	4.00	5.00
42	Cement rubble masonry	2,342 cy	38.00	36.00	30.00
52	Class B cement concr. paving for stream beds, 6-in. depth	4 cy	50.00	50.00	40.00
53	Grouted rubble paving for stream beds	3 cy	20.00	50.00	35.00
54a	Type F-2 endwall including rails	1 ea	200.00	150.00	400.00
55	Manhole	1 ea	400.00	250.00	250.00
56	Type D inlet	1 ea	200.00	125.00	250.00
56a	Type E inlet	5 ea	200.00	115.00	250.00
56b	Type E inlets with sumps	6 ea	300.00	150.00	225.00
56c	Type H inlets	12 ea	300.00	200.00	275.00
56e	Type G inlet	1 ea	200.00	150.00	350.00
56f	Inlet—4 ft.	1 ea	300.00	200.00	410.00
57	Rebuilt manholes	2 vf	40.00	30.00	25.00
60	Cast-iron pipe, 18 in., interlocking style	42 lf	3.00	7.00	8.90
61	Corrugated metal pipe—15 in.	160 lf.	3.50	2.70	4.20
61a	Corrugated metal pipe—18 in.	20 lf	4.00	3.25	4.50
65	Reinforced cement concrete pipe—15 in	690 lf	4.50	3.50	4.80
65a	Reinforced cement concrete pipe—18 in	2,562 lf	5.00	4.00	8.00
65b	Reinforced cement concrete pipe—24 in	394 lf	6.50	6.00	7.20
65c	Reinforced cement concrete pipe—30 in.	242 lf	10.00	9.00	10.50
65g	Extra strength reinforced cement concr. pipe—24 in.	128 lf	7.00	6.00	7.80
66	Plain cement concr. or vit. clay pipe —15 in	452 lf	3.50	3.00	3.40
66a	Plain cement concr. or vit. clay pipe —18 in	120 lf	4.00	4.00	4.10
66b	Plain cement concr. or vit. clay pipe —24 in	26 lf	4.25	6.00	8.90
67a	Terra cotta pipe, 15 in., relaid	234 lf	2.50	3.00	2.70
69	Tile underdrain—4 in	2,108 lf	1.40	1.30	2.15
69a	Tile underdrain—6 in	1,090 lf	1.50	1.50	2.30
71	Tile outlets—4 in	110 lf	1.00	1.00	2.30
71a	Tile outlets—6 in	30 lf	1.25	1.10	2.45
72	Treated timber cribbing	4.2 Mbm	300.00	275.00	500.00
74	Coarse aggregate for extra depth tile underdrain	5 cy	5.00	7.00	5.40
75	Subgrade drains	1,400 lf	.70	.70	.80
78	Plain cement concrete gutter, type C	2 sy	10.00	5.00	5.40

Potholes Dam, Columbia Basin Project, Washington

OWNER: Bureau of Reclamation, Coulee Dam, Washington.

PROJECT: Construction of Potholes Dam on Crab Creek about 15 miles west of Warden, Washington. Project involves the construction of about 19,000 ft. of nearly continuous embankment, of varying height up to approximately 200 ft., across depressions in Crab Creek Basin; an outlet works in tunnel near the east end of the dam; a 500 ft. wide open channel spillway between sections of the embankment; and a roadway extending the full length of the crest of the dam. The dam will consist mainly of moistened and rolled embankments of clay, sand, and gravel, with outer sections of sluiced gravel fill. Upstream slopes of the embankments will be covered with a 3 ft. layer of rock riprap, and downstream slopes will have a 2 ft. rock surfacing. The outlet works will consist mainly of a concrete-lined tunnel about 700 ft. long of 7½ ft. diameter circular section, inlet and outlet structures, and a concrete-lined vertical shaft of 6 ft. diameter circular section providing access to a gate chamber in an enlarged section of the tunnel near the axis of the dam. Flow through the outlet tunnel will be controlled by a 4x4 ft. high-pressure slide gate in the plug concrete in the gate chamber. Discharge through a 22 in. diameter outlet pipe will be controlled by an 18 in. emergency gatevalve in the gate chamber and an 18 in. hollow-jet operating valve in the tunnel outlet structure. The roadway will be constructed between concrete curbs along the crests of the dam embankments and through adjoining rock cuts and will be surfaced with gravel or crushed rock.

CONDITIONS: The nearest railhead is 15 miles east, at Warden, Washington. Contractor must furnish cement and admixture for concrete, mortar, and grout; steel tunnel-liner plates for permanent tunnel supports; all gravel or rock spall for filling spaces back of steel tunnel-liner plates; all form materials; temporary supports; and all other materials not a part of the completed construction work. Contract time is 1400 calendar days. Wage rates are power shovel operators, $1.85 per hour; electricians, $1.75; cement finishers, $1.675; pipefitters, $1.65; rock crusher operators, $1.60; carpenters, $1.575; concrete mixer operators, $1.50; and common laborers, $1.05.

Potholes Dam, Columbia Basin Project, Washington

(Continued from preceding page)

BIDS: Four bids were received August 15, 1946, ranging from the contract low of $9,359,011.00 to $11,168,479.00. Contract was awarded on October 24, 1946.

LIST OF BIDDERS:

1. C. F. Lytle Co., Sioux City, Ia.; Green Const. Co., Des Moines, Ia.; and Amis Const. Co., Oklahoma City, Okla. (contract)	$9,359,011.00
2. Bressi and Bevanda Constructors, Inc., Los Angeles, Calif.; A. Teichert & Son, Inc., Sacramento, Calif.; M. E. Keir Const. Co., Los Angeles, Calif.; and Guy F. Atkinson Co., So. San Francisco, Calif	9,584,677.00
3. Morrison-Knudsen, Inc., Seattle, Wash.; Peter Kiewitt Sons Co., Seattle, Wash.; Utah Const. Co., San Francisco, Calif.; S. Birch & Sons Const. Co., Great Falls, Mont.; Winston Bros. Co., Los Angeles, Calif.; McLaughlin, Inc., Los Angeles, Calif.; and C. & F. Trucking and Contracting Co., Butte, Mont.	10,448,000.00
4. J. A. Terteling & Sons, Inc., Boise, Idaho	11,168,479.00

Item	Quantity	Unit Prices		
		(1)	(2)	(3)
1 Diversion and care of river during construction and unwatering foundations	lump sum	$40,000.00	$178,000.00	$225,661.00
2 Excavation, stripping borrow-pits	600,000 cy	0.32	0.22	0.25
3 Excavation, common, for spillway	380,000 cy	0.50	0.45	0.50
4 Excavation, rock, for spillway	480,000 cy	1.32	1.75	1.70
5 Excavation, common, in open cut for outlet works	1,400 cy	0.88	1.40	2.50
6 Excavation, rock, in open cut for outlet works	5,000 cy	2.65	3.20	2.50
7 Excavation, all classes, in tunnel and shaft	2,600 cy	16.90	42.00	35.00
8 Furnishing and installing steel tunnel-liner plates	10,000 lb	0.25	0.25	0.30
9 Excavation, common, for foundations of dam	535,000 cy	0.66	0.50	1.00
10 Excavation, rock, for foundations of dam	60,000 cy	2.65	3.00	3.25
11 Excavation, all classes, for grout caps in dam foundations	4,800 cy	16.90	19.00	20.00
12 Excavation, common, for roadway	2,000 cy	0.47	2.00	2.50
13 Excavation, rock, for roadway	2,300 cy	1.70	2.00	2.50
14 Excavation, common, in borrow-pit No. 1 and transportation to dam embankments	1,150,000 cy	0.448	0.44	0.40
15 Excavation, common, in borrow-pit No. 2 and transportation to dam embankments	3,500,000 cy	0.504	0.49	0.60
16 Excavation, common, in borrow-pit No. 3 and transportation to dam embankments	4,900,000 cy	0.591	0.45	0.60
17 Earthfill in embankments	5,000,000 cy	0.176	0.28	0.21
18 Sluiced sand and gravel fill in embankments	3,600,000 cy	0.147	0.20	0.16
19 Tamping or puddling earth fill	50,000 cy	2.28	3.00	2.50
20 Rock surfacing on downstream slopes of embankments	180,000 cy	0.50	0.38	0.40
21 Riprap on upstream slopes of embankments	400,000 cy	0.50	0.32	0.30
22 Road surfacing	10,000 cy	2.95	2.75	3.35
23 Drilling weepholes	250 lf	2.20	2.20	1.50
24 Core drilling 5½-inch diameter holes not more than 30 feet deep	1,000 lf	18.75	11.50	12.00
25 Drilling grout holes in stage between depths of 0 foot and 35 feet	15,000 lf	1.55	3.00	2.25
26 Drilling grout holes in stage between depths of 35 feet and 60 feet	10,000 lf	3.15	3.00	2.25
27 Drilling grout holes in stage between depths of 60 feet and 110 feet	2,500 lf	4.00	3.00	2.25
28 Drilling grout holes with percussion drills	15,000 lf	1.25	1.25	1.00
29 Placing grout pipe and fittings	22,000 lb	0.25	0.30	0.42
30 Pressure grouting	40,000 cf	1.90	2.00	2.00
31 Pressure grouting with packers	7,500 cf	2.50	2.50	2.15
32 Furnishing and handling cement	30,000 bbl	5.45	4.00	5.00
33 Concrete in grout caps	4,800 cy	12.75	15.00	14.00
34 Concrete in tunnel lining	900 cy	48.90	60.00	48.00
35 Concrete in trashrack structure and transition	75 cy	60.00	54.00	62.00
36 Concrete in shaft and gate chamber	260 cy	59.40	60.00	70.00
37 Concrete in tunnel outlet structure	100 cy	47.20	70.00	50.00
38 Concrete in gate chamber plug	60 cy	29.50	40.00	45.00
39 Concrete in spillway	750 cy	17.50	22.00	17.00
40 Concrete in curb walls	2,450 cy	39.20	54.00	35.00
41 Placing reinforcement bars	250,000 lb	0.05	0.05	0.06
42 Placing metal sealing strips	90 lf	1.70	1.50	2.00
43 Construction of valvehouse, except concrete	lump sum	280.00	600.00	1,000.00
44 Installing hollow-jet valve	1,600 lb	0.28	0.12	0.15
45 Installing high-pressure gate and conduit linings	45,000 lb	0.055	0.07	0.08
46 Installing high-pressure gate control piping	1,000 lb	0.42	0.60	0.30
47 Installing outlet pipe	24,000 lb	0.06	0.07	0.30
48 Installing trashrack metalwork	11,000 lb	0.04	0.12	0.10
49 Installing miscellaneous metalwork	9,200 lb	0.12	0.45	0.37

Storm Sewer Improvements Oklahoma City, Okla.

OWNER: City of Oklahoma, J. S. Waldrep, Consulting Engineer.

PROJECT: Improvements to existing storm sewers in south part of Oklahoma City. Work involves removal of sidewalk, pavement, trees, and old pipe, and laying of 38,950 lin. ft. of new sewer pipe.

CONDITIONS: The Oklahoma City Junction Railroad serves the city. All materials are to be furnished by the contractor. Contract time is 6 months. Skilled labor wage rates approximate $1.50 per hour, semi-skilled, $1.25, and common labor, $.90.

BIDS: Seven bids were received November 6, 1946, ranging from the contract low of $297,911.96 to $359,154.30. The low bid was 10 percent below the engineer's estimate of $330,536.90.

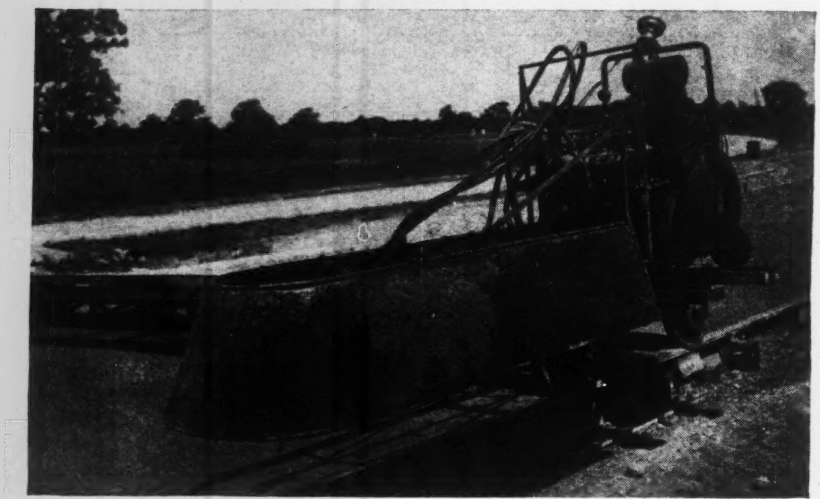
LIST OF BIDDERS:

1. Earl W. Baker & Co. (contract)	$297,911.96
2. Spicers Construction Co.	319,139.60
3. B. & M. Construction Co.	324,402.88
4. Koller Construction Co.	327,431.25
5. P. C. Sorenson & Co.	328,816.65
6. Osage Construction Co.	329,474.55
7. Sherman Machinery & Iron Works	359,154.30

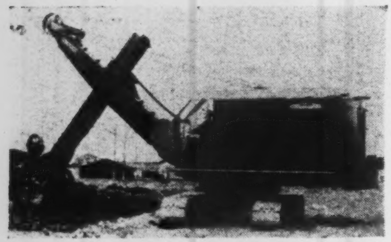
Item	Quantity	Unit Prices		
		Engineer's Estimate	(1)	(2)
1 Sewer pipe—15″	300 lf	$2.25	$2.17	$2.25
2 Sewer pipe—18″	2,730 lf	2.50	2.57	2.50
3 Sewer pipe—21″	1,140 lf	3.00	2.79	3.00
4 Sewer pipe—24″	6,740 lf	4.30	3.75	4.05
5 Sewer pipe—27″	3,050 lf	5.25	4.41	4.60
6 Sewer pipe—30″	5,880 lf	6.00	5.36	5.26
7 Sewer pipe—33″	5,310 lf	6.75	6.22	5.63
8 Sewer pipe—36″	5,040 lf	7.70	6.72	7.00
9 Sewer pipe—42″	2,910 lf	10.50	8.61	9.50
10 Sewer pipe—48″	4,500 lf	12.50	10.89	12.50
11 Sewer pipe—54″	1,350 lf	15.00	11.88	13.50
12 Single grate inlets	13 ea	80.00	96.00	105.00
13 Double grate inlets	100 ea	120.00	148.00	170.00
14 Box type inlets	27 ea	70.00	77.00	70.00
15 Manholes, design No 1	84 ea	140.00	133.00	175.00
16 Manholes, design No. 3	33 ea	160.00	203.00	250.00
17 Junction box No. 1	1 ea	150.00	230.00	150.00
18 Pavement removed	3,090 sy	1.50	1.60	1.00
19 Driveway removed	1,360 sf	0.20	0.14	0.25
20 Sidewalk removed	350 sf	0.10	0.10	0.25
21 Concrete pavement—6″	880 sy	3.00	2.60	4.00
22 Asphalt pavement	2,040 sy	4.00	3.60	5.50
23 Concrete driveway—6″	1,360 sf	0.40	0.32	0.40
24 Concrete sidewalk—4″	350 sf	0.30	0.25	0.35
25 Single grate inlets removed	3 ea	15.00	18.00	15.00
26 Manhole removed	1 ea	30.00	50.00	50.00
27 Headwalls	3 ea	200.00	75.00	100.00
28 Corrugated pipe removed—42″	44 lf	3.00	2.09	4.00
29 Concrete pipe removed—15″	26 lf	1.20	1.00	1.25
30 Concrete pipe removed—21″	237 lf	1.60	1.40	1.50
31 Concrete pipe removed—30″	30 lf	2.20	1.60	3.00
32 Trees 6″ & under removed	63 ea	15.00	8.00	5.00
33 Tree over 6″ removed	24 ea	25.00	20.00	10.00
34 Fire hydrant reset	3 ea	60.00	67.00	25.00
35 Water meter reset	20 ea	10.00	15.00	5.00
36 Concrete curb	700 lf	0.75	0.80	0.75
37 Concrete curb & gutter	1,970 lf	1.25	1.30	1.25
38 Excavation	200 cy	2.00	0.90	0.50
39 Class A concrete	15 cy	30.00	32.00	25.00
40 Reinforcing steel	1,000 lb	0.10	0.09	0.10
41 Brick wall—8″	200 sf	2.00	1.20	1.25
42 Cast iron pipe—8″	16 lf	5.00	3.25	3.00
43 Inverted siphon	1 ea	1,500.00	1,800.00	750.00

New Aids to the Constructor

MANUFACTURERS' LATEST DEVELOPMENTS IN EQUIPMENT AND MATERIALS



Curing Compound Application Machine—A distinctive feature of the Tru-Cure curing compound application machine is the multiple nozzle spray which is hidden by the hood or windshield. The nine nozzles are arranged to provide complete coverage of a 5-ft. swath sweeping transversely across a road strip. The gasoline engine, pump and tank are mounted on wheels operating on a railway running back and forth on a bridge crossing the roadway. The bridge in turn is on wheels and operates on rails; it is moved ahead by a crank and ratchet mechanism. Curing compound is deposited at the rate of 200 sq. ft. per gal., providing a film heavy enough for proper water retention. One operator, it is claimed, can readily keep up with the concrete road-laying team.—*The Truscon Laboratories, Detroit, Mich.*

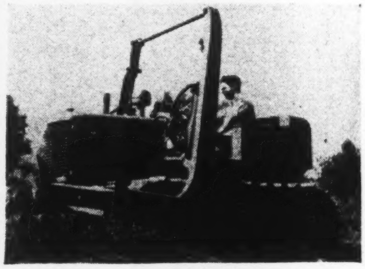


Crawler and Wheel Cranes—"Smooth as steam" air-control is a feature of Osgood's new Type 81 shovel-crane-backhoe rig in crawler or wheel mounting. Crawler mounted machines are: Model 810, 1½ cu.yd. capacity Model 816, 1¾ cu.yd. and Model 817 with wide treads for dragline, clamshell and crane service. Model 815 is the mobilcrane counterpart, a self-propelled, one-man operated unit on 12 or 18 pneumatic tires.

From a control panel of short-throw levers metering type air valves are operated to deliver the right amount of air to the several required operations—hoisting, crowding, swinging, traveling and steering motions. The latter is accomplished by air taken down the vertical shaft to operate steering clutches and brakes. The unit is built for rugged use with maximum safety.—*The Osgood Company, Marion, Ohio.*

Safety Hose—Developed by *Darin & Armstrong*, Detroit contractors, new safety air hose bypasses current around operator of drill or pneumatic concrete buster to prevent serious accidents caused by drilling into underground high-tension lines. Based on theory that electric current takes path of least resistance, hose consists of spiral of 832 braided stands of No. 30 bare copper wire embedded in Neoprene synthetic rubber. When properly grounded, hose has resistance of less than 0.06 Ohms, as compared with 200 to 1,000 Ohms for human body. When drill point strikes high-tension wire, current shorts through hose, even if operator is standing on damp ground. When used with plant air supply lines, grounding is automatic; if used with portable compressors, adequate ground must be provided. Under license with contractors, who have applied for patent, hose is being manufactured by *Mercer Rubber Co., Hamilton Square, N. J.*

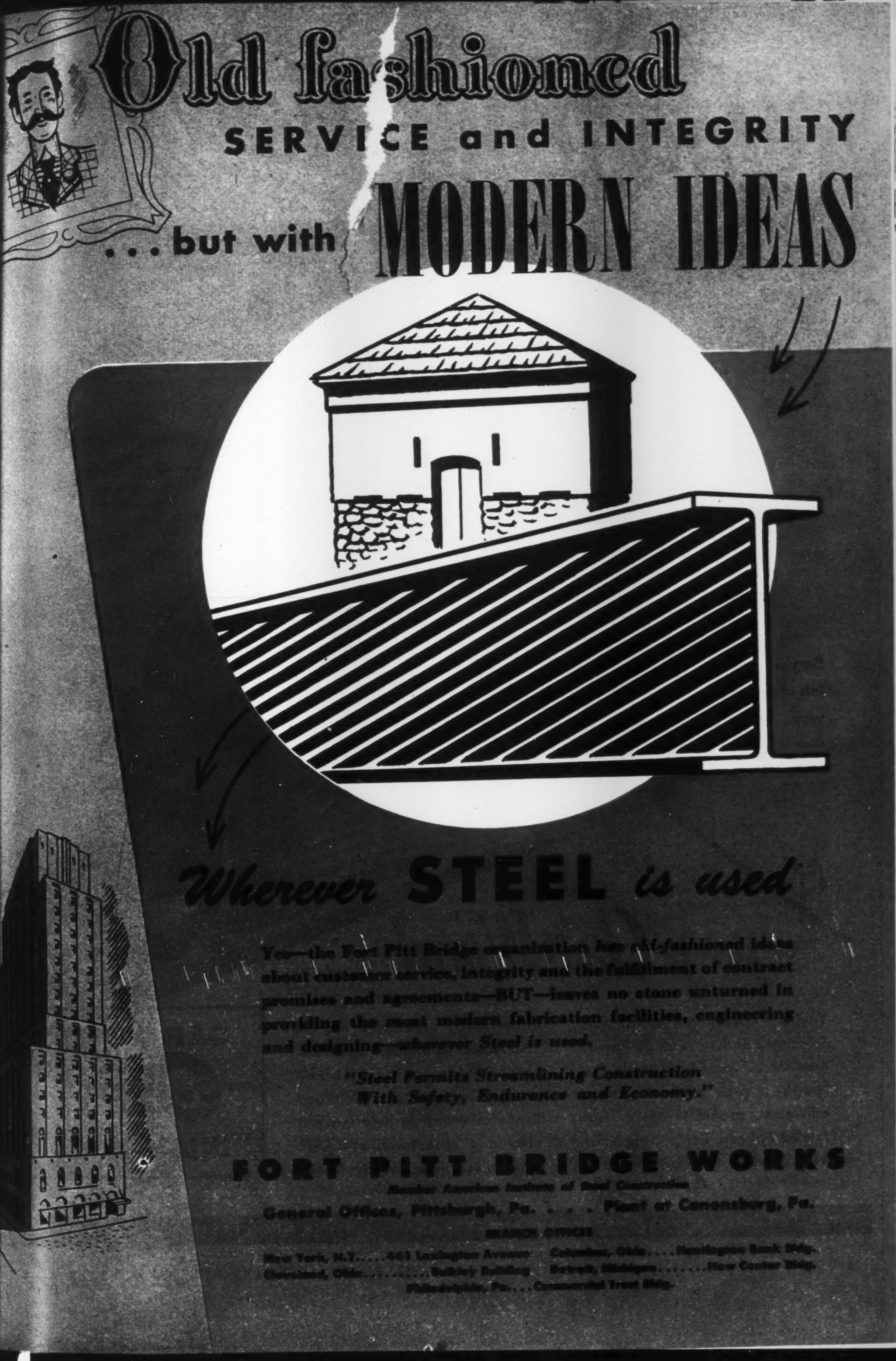
Soil Sampler—For securing undisturbed soil samples in material in which it is difficult or impossible to recover them by the open tube method, the Cannon "Shurshot" sampler has been designed to get an almost watertight shut-off. The special 32-in. long tool is designed to work on the end of a standard drill and to be driven by the small drop hammer on the drill stem to the depth required. Where it is desired to take the sample, the drill stem is rotated with a wrench to force closing of spring at the lower part of the unit to hold an intact sample.—*Cannon Diamond Drilling Co., P. O. Box 549, Compton, Calif.*



Bulldozers and Gradebuilders—Bulldozers and gradebuilders developed specially for the new Allis-Chalmers 2 cycle, diesel powered HD-5, were designed to match tractor power, size, and speed, built to maintain tractor balance, stability and traction and mounted to save wear, tear and maintenance.

The HD-5 is a small tractor featuring a drawbar pull of 37.4 hp., with five speeds from 1.46 to 5.47 mph, 1,000 hr. roller and idler lubrication, full visibility for the operator, and simplified maintenance. — *Baker Manufacturing Co., Springfield, Ill.*

Centrifugal Pumps—A new line of "Pedrifugal" pumps, is said to meet the needs of an unusually wide range of users who require a sturdy, reliable pump of moderate capacity selling at a competitive price. This line of cast iron bronze-fitted, pedestal-type cen-



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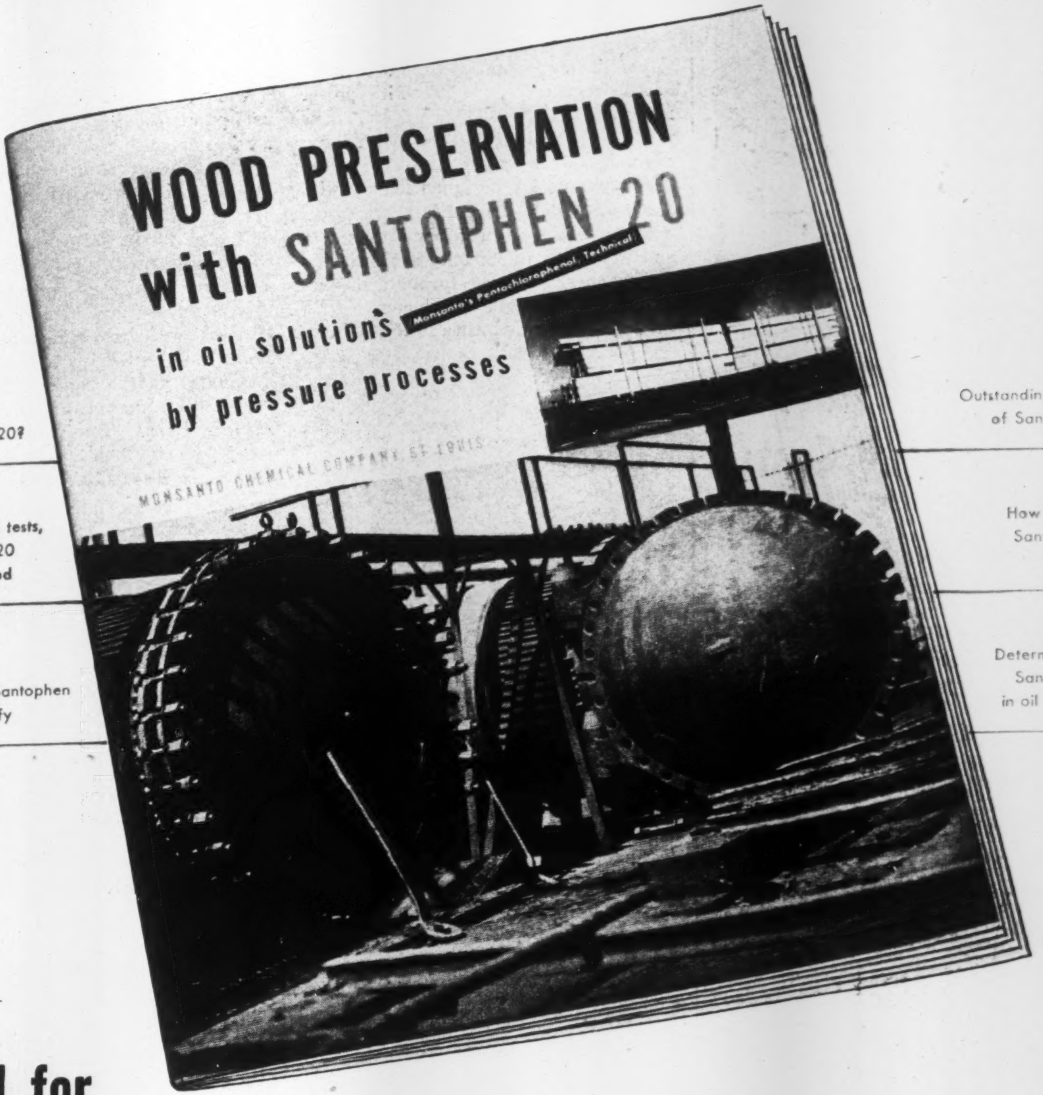

WOOD PRESERVATION with SANTOPHEN 20 Monsanto's Pentachlorophenol, Technical in oil solutions by pressure processes

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This subject is particularly timely. Included in this book you will find a summary of advantages of Monsanto Pentachlorophenol, Technical, applied in oil solutions by pressure processes.

Much information is given on comparative toxicity of preservatives, water solubility, vapor pressure, concentrations for adequate treatments, and the determination of Santophen 20* in oil solutions and untreated wood.

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Enduring!
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Maintenance Costs!

Klemp steel surface flooring stands up under severest traffic, shock and impact. *Proved by long use.*

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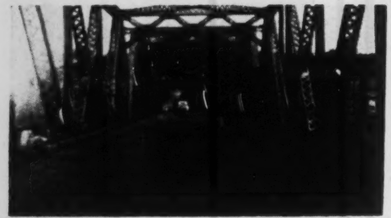
HEXTEEL
HEAVY DUTY SURFACE ARMOR
for **HIGHWAYS**
BRIDGES • VIADUCTS

Heavy duty steel grid specially designed to be imbedded in concrete or mastic over old or new surfaces, 12- and 14-gauge thicknesses, ¾", 1", and 1¼" depths. Units 3 x 10 ft., or cut to fit any area, around obstructions. Joining easily done, making solid, *one-piece* surface. Concrete or mastic "wood floated" flush with top, and tamped or troweled. (see left above.) Exposed top of steel grid takes brunt of traffic.



Bridge floored with Hexteel many years ago. Good as new.

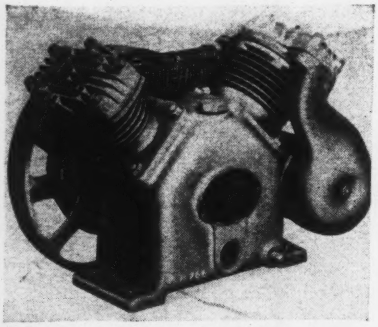
Send for Complete Klemp Catalog

Also shows Klemp Floorsteel, armor that rolls out like a rug. Open Steel Gratings, welded and riveted, Steel Stair Treads, Steel Safety Mats. Wire or write

Wm. F. Klemp Co.
6608 S. Melvina Ave., Chicago 38, Ill.

trifugal pumps comes in three principal sizes—1x1 in., 2x2 in. and 3x3 in. Capacities are from 10 to 500 gpm. at heads from 10 to 100 ft., with power requirements from ¼ to 15 hp. The units are splatter-finished with gray enamel.

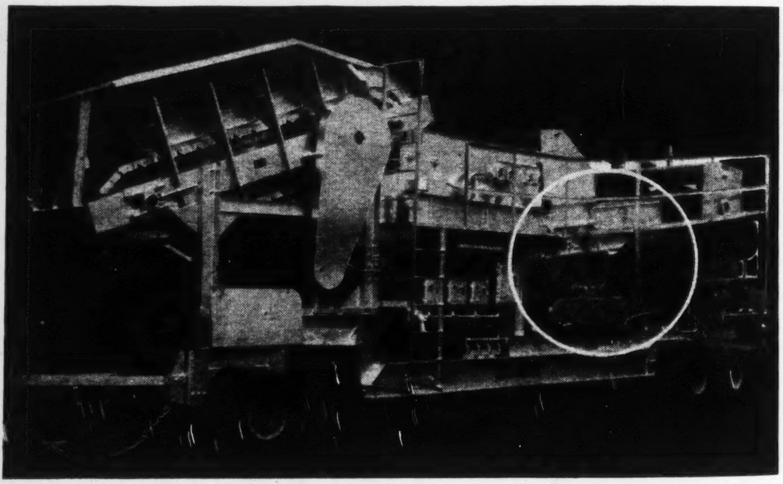
The pumps are designed for use with Texrope V-belt drives; all are fitted with impellers of maximum diameter, and variations in capacity are provided by changes in speed through sheaves of larger or smaller diameter.—*Allis-Chalmers Mfg. Co., Milwaukee, Wis.*



Air Compressors— A new line of "Air King" air compressors includes single-stage and two-stage sizes for pressures up to 250 psi. for use with standard motors of 1 to 15 hp. inclusive. Arrangements include self-contained power driven models mounted on bases or tanks as well as bare compressors for either direct or V-belt connection to drivers. The compressors supply air for a wide variety of industrial uses such as paint-spraying, operating pneumatic controls, etc.

This line introduces a new principle in automatic starting of compressors. A centrifugal clutch permits the driving motor to attain full speed before the compressor turns. This eliminates the need for starting unloaders, check valves, release and bleeder valves, etc. Direct power drive eliminates transmission losses and drive adjustments. An adequate guard incloses all moving parts—*Worthington Pump and Machinery Corp., Harrison, N. J.*

Ductless Dust Collector—A self-contained recirculating type dust collector with large storage and suction capacity and a dustless means of removing large volumes of collected dust, Model 11w50 Dustkop, consists of a motor-driven suction and cleaning unit, a supporting stand and two roller cans. Requiring only 8 sq. ft. of floor space, the entire system can be located immediately behind the source of the dust. No floor or wall cutting for installation of duct work is needed. The unit is rated at 1,400 cfm. on a single 6-in. inlet and will develop a static suction ranging up to 7.9 in. of water on a single 4 in. inlet.—*Aget-Detroit Co., Ann Arbor, Mich.*



Portable Crushing Plant — Reaching and supplying crushing markets anywhere, at any time, the new Dixie portable crushing plant reduces quarry-run stock to minus 1 inch or to agstone size in one operation. It is said to crush 100 to 150 tons per hour. Producing any combination of sizes from 85 percent rock to 100 percent agstone, it takes wet or sticky material without clogging. Feed is direct from shovel; no intermediate conveyors or trucks are required. Plant includes: 40 in. x 10 ft. apron feeder; 4 x 8 ft. 2-deck vibrating screen; 36 in. belt conveyor; Caterpillar engine. Complete unit is mounted on a chassis with 24 pneumatic-tired wheels. Crusher is driven by V-belts, other equipment by individual motors, powered by separate generator set.—*Dixie Machinery Mfg. Co., St. Louis and New York.*

...and 3 Plants Operating as One.

Fabricators and Erectors of Structural Steel

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Fabricating and erecting bridges is one activity, in our plants, where the flexibility of our set-up provides abundant facilities for moving fast.

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Fabricating the structural steel and erecting highway bridges is just one of our activities. We also fabricate and erect structural steel for all types of buildings . . . industrial plants, public buildings, churches, apartments, stadiums, and so forth.

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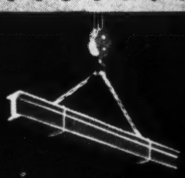
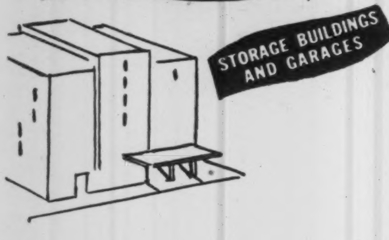


(Reproduction of Advertisement appearing in Fortune Magazine)

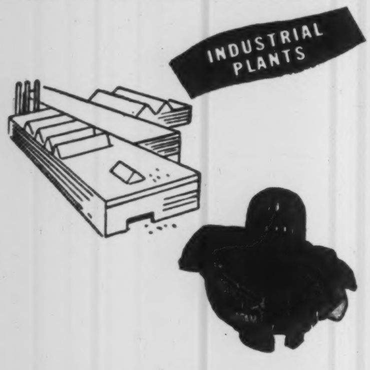
Multiplicity of Equipment Breaks Bottlenecks Wide Open!

DRAINS
FOR EVERY PROJECT
ARE MADE BY Josam



Series 0320 Ramp Drain

Series 050 Bridge Drain



Series 490 G. C. Roof Drain

Josam makes hundreds of types of floor, roof, shower drains and other types of drains and drainage products to meet the needs of every type of building. To save time and money, check your drainage requirements with Josam. Send for literature applying to your particular project.

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Representatives in all Principal Cities
JOSAM PACIFIC CO.
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EMPIRE BRASS CO.
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Manufacturers' Activities

Because of the rapidly expanding business activity in the Southwest, CUTLER-HAMMER, INC., Milwaukee, Wis., manufacturers of electric motor controls and allied products, has established Dallas, Tex., as a new district sales territory, replacing the former branch sales office operation. The district will be under E. K. Anderson, district manager, at 715-A N. Ervay St., Dallas, and includes Texas, Oklahoma, Arkansas and southern New Mexico. J. S. Darby will be in charge of the company's branch sales office in Houston, and will operate under the supervision of the Dallas office.

H. K. PORTER CO., INC., has elected C. R. Dobson as vice president in charge of operation. Mr. Dobson, formerly chief industrial engineer of the Jones & Laughlin Steel Corp., will supervise operations of the seven Porter manufacturing plants.

JAMES M. BORROR has been appointed Northwest district representative of The Galion Iron Works & Mfg. Co., covering the states of Washington, Oregon, Idaho, Montana, and Wyoming.

A SPECIAL ISSUE of *"The Eutectic Welder"* contains some unusual photographs showing applications of the company's products to wartime metal joining problems. Of particular interest are three photo-micrographs taken at 500 diameters which vividly show the perfect bonds possible through the use of the company's products.—*Eutectic Welding Alloys Corp., 40 Worth St., New York 13, N. Y.*

Appointment of ROBERT C. FRIEDLY as construction specialist for Nelson Sales Corp. of Lorain, Ohio, has been announced. Mr. Friedly's background includes several years of experience as an independent contractor and sales engineer for construction materials. He served as an officer in the U. S. Army, joining the Nelson organization shortly after his recent discharge. His initial assignment will be to establish complete application specifications for Nelson stud welding in construction.

M. A. CLEMENTS has been appointed service manager for the western division of Caterpillar Tractor Co. at San Leandro, Calif. Mr. Clements joined the Caterpillar organization in 1936.

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Pensacola—Ray-Brooks Truck & Tractor Company
GA......Atlanta—Tri-State, Inc.
Albany—Tri-State Tractor Company
IDA.....Boise & Pocatello—Intermountain Equipment Co.
ILL.....Peoria & Springfield—A. E. Hudson Company
Salem, Carmi—E. W. Werner Equipment Company
Chicago—R. C. Larkin Co.
IND.....Indianapolis—Indiana Equipment Co., Inc.
Evansville—Brandeis Machinery & Supply Co.
IOWA...Des Moines—Herman M. Brown Company
KANS....Wichita—S. H. Denney Road Machinery Co.
KY......Louisville—Brandeis Machinery & Supply Co.
LA......Baton Rouge, Monroe, New Orleans—Dunham-Pugh Co., Inc.
MAINE.Portland—Maine Truck-Tractor Co.
MD.....Baltimore—Phillips Machinery & Tractor Co.
MASS...Newton Upper Falls—United Equipment Corp.
MICH...Bark River—Bark River Culvert & Equipment Co.
Detroit and Grand Rapids—
Wolverine Tractor & Equipment Co.
MINN...Minneapolis & Duluth—Rosholt Equipment Co.
MISS...Jackson—Mississippi Road Supply Co.
MO.....St. Louis—Missouri-Illinois Tractor & Equip. Co.
Kansas City—Noel V. Wood, Inc.
MONT..Billings & Missoula—Industrial Equipment Co.
Great Falls—Hi-Line Equipment Co.
NEB....Omaha—Nebraska Tractor & Equipment Company
North Platte—Cornhusker Tractor & Equip. Co.
NEV.....Reno—Brown Motors
N. H....Manchester—R. C. Hazelton Co.
N. M....Albuquerque—Hardin & Coggins, Inc.
N. Y.....Buffalo—Dow & Company, Inc.
Brooklyn—Edward Ehrbar, Inc.
Albany, Syracuse—Milton-Hale Mach. Co.
N. C.....Raleigh—J. B. Hunt & Sons
N. D....Fargo—Myhra Equipment Company
OHIO...Cleveland—Gibson-Stewart Company
Cincinnati—Rish Equipment Co.
Cambridge—Major Equipment Co.
Richwood—Hamilton Equipment Co.
OKLA...Tulsa & Guthrie—C. L. Boyd Company, Inc.
ORE....Portland & Eugene—Howard-Cooper Corporation
PA......East Butler—Walsh Equipment Co.
Pittsburgh—Atlas Equipment Corp.
Philadelphia—Service Supply Corp.
Harrisburg & Wilkes-Barre (Kingston)—
State Equipment Co.
R. I.....Providence—Tractors, Inc.
S. C.....Columbia—N. H. Summers Road Machinery Co.
S. D.....Sioux Falls, Rapid City—Empire Equipment Company
TENN...Knoxville & Chattanooga—Power Equipment Co.
Nashville—Industrial Tractor & Equipment Co., Inc.
Memphis—Road Builders Equipment Co.
TEXAS..Dallas & Houston—Browning-Ferris Machinery Co.
San Antonio—Jess McNeel Machinery Co.
Plainview, Abilene, Odessa—Plains Machinery Co.
El Paso—Hardin and Coggins, Inc.
UTAH...Salt Lake City—The Lang Company
VA......Richmond and Roanoke—Rish Equipment Co.
Alexandria—Phillips Machinery & Tractor Co.
WASH..Seattle—Howard-Cooper Corp.
Spokane—Intermountain Equipment Co.
W. VA...Charleston and Clarksburg—Rish Equipment Co.
WIS.....Milwaukee, Eau Claire & Green Bay—Bark River Culvert & Equipment Co.

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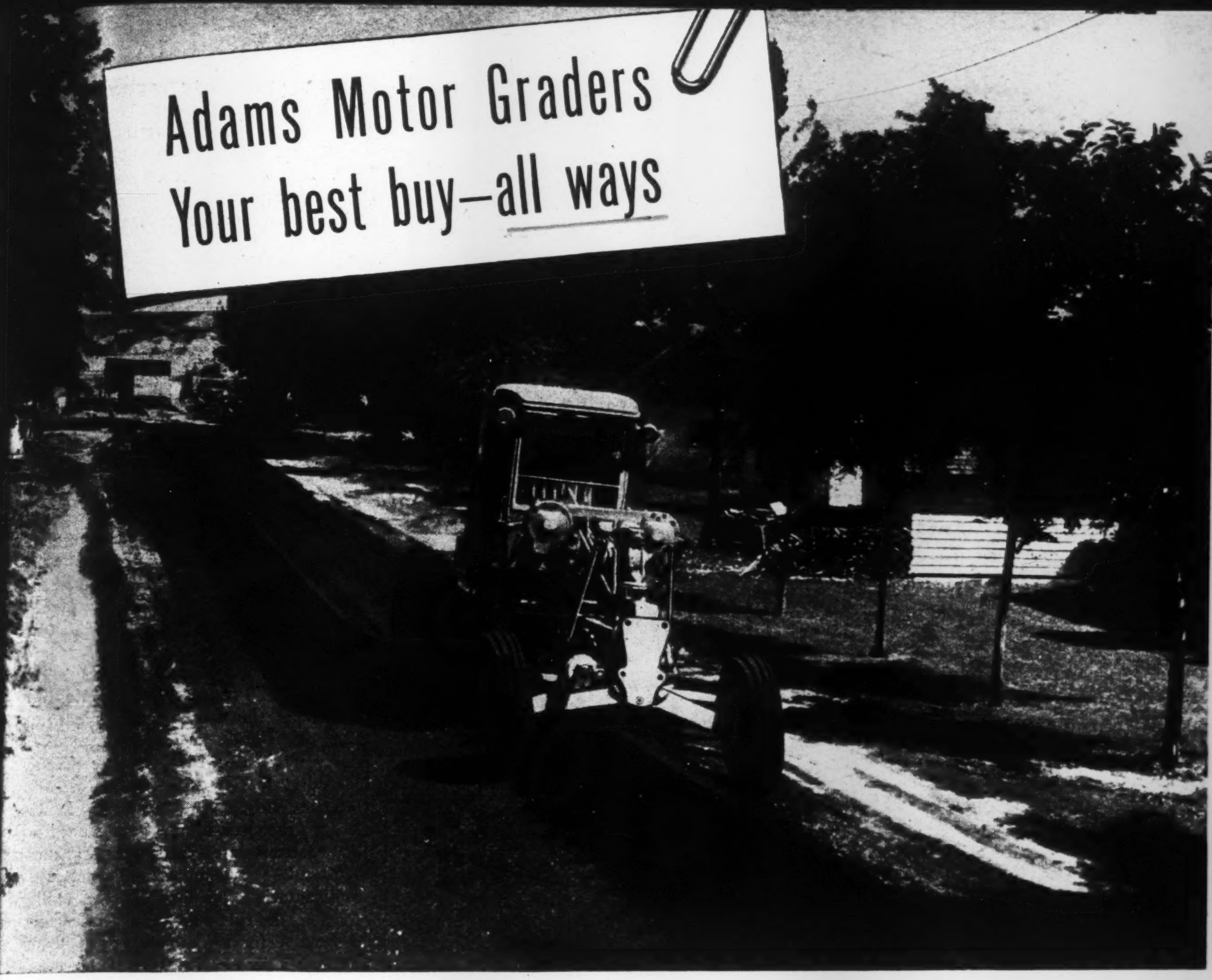

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PROVIDES MORE CLEARANCE—TO DO MORE WORK—FASTER!

THE high-arch front axle is one of the biggest recent developments in motor grader design. And only in Adams Motor Graders is this important advantage available in several models and sizes.

Here is an advancement that approximately doubles front-axle capacity—eliminates front-axle bulldozing. In short, the high-arch front axle enables Adams Motor Graders to straddle far larger windrows of earth and oil mix—move more material, better, faster, cheaper . . . without waste of power or loss of operating speed.

You have only to see Adams' high-arch front axle to know that here is an advantage you'll surely want in your new graders. And it's only one of the many important advantages you'll find in Adams machines. Let your local Adams dealer show you why Adams Motor Graders are *your best buy—all ways.*

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Motor Graders
Elevating Graders
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Heavier loads
...faster schedules

Truck operators, confronted with increased costs, are solving this particular problem by using more powerful trucks . . . hauling *heavier loads* on *faster schedules.*

For your big trucks and tractors, assure these profit-making advantages by specifying the sub-assemblies. To get the exact balance . . . the maximum efficiency from your entire truck, specify Fuller Heavy-duty Transmissions . . . the transmission designed by specialists to give you longer wear-life *plus* top performance.

Model SA920
Fuller
TRANSMISSIONS

FULLER MANUFACTURING CO., TRANSMISSION DIVISION
KALAMAZOO 13F, MICHIGAN
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CAST-IN-PLACE CONCRETE COMPOSITE
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BOSTON • CINCINNATI • NEW ORLEANS

Following a two-year engineering apprentice course he spent a year in the company's research laboratory, joining the service department in December, 1939. In 1943 he became service engineer and, a year later, was named central division service manager.

LINCOLN ELECTRIC CO., Cleveland, Ohio, announces the appointment of R. W. Sharp as district manager and sales engineer of its new Indianapolis office. Mr. Sharp joined the company in 1939 and has acquired broad experience in welding engineering.

GILMORE HIETT has become advertising and sales promotion manager of the Gorman-Rupp Co., pump manufacturers of Mansfield, Ohio. He had previous experience as advertising manager for refrigerators and home freezers with the Westinghouse Electric Corp. and was advertising manager of the Mansfield News-Journal and the Marion (Ohio) Star.

R. G. LE TOURNEAU, INC., Peoria, Ill., announces the moving of its eastern sales office and the appointment of a new central sales manager. The office is located at 1026 17th St., N. W., 412-413 Defense Bldg., Washington 6, D. C. O. A. (Jack) Williams was named to the eastern sales managership after serving LeTourneau as a district sales representative in 1944. W. B. (Bill) Worden, district sales and service representative for LeTourneau in southern California and Arizona for the past four years, has been named central sales manager for the company.

S. V. SAGINOR, for the past six years general manager of the Davey Compressor Co., Kent, O., has been named vice president and a director of the Robinson Clay Products Co., Akron, O., succeeding Thomas Rockwell, who is retiring as vice president and treasurer after 42 years. Paul V. Robinson, formerly secretary, now has the combined post of secretary-treasurer.

THE AMERICAN MANGANESE STEEL DIVISION of American Brake Shoe Co., Chicago Heights, Ill., announces three major appointments: A. R. Sittig, manager of manganese steel sales and E. L. Quinn, assistant vice-president in charge of welding products, at Chicago Heights, Ill.; and E. J. Nist, assistant vice-president at 230 Park Ave., New York, N. Y.

L. J. RENNER has been appointed mid-continent wire rope sales manager for the Wickwire Spencer Steel division of The Colorado Fuel and Iron Corp. He will be located at 1502 Fort Worth National Bank Bldg., Fort Worth 2, Texas. He previously handled the sale

FRAMEWORK...

AN ELECTRIC IRON...

use fasteners

bolts - nuts - rivets - screws

for DEPENDABILITY, SECURITY, ECONOMY...

In fabricating and joining the structural members of a bridge or steel-frame building, *dependability* and *security* are vital!

Make your connections by bolting or riveting—and there need be no uncertainty about the strength or condition of the joint. The fastener itself is a well-known product, checked and inspected—and providing recognized physical values. Time-proved engineering calculations are used in the design of the joint, and its soundness is readily determined by visual inspection. There are no great locked-up internal thermal-contraction forces within the bolted or riveted structure to detract from their usable strength.

Economy is always important—and fabrication by fasteners brings welcome savings. For example, their use imposes no limitations as to the chemical or physical properties of the metal used for the structural members. The lowest cost steel can be used without fear of trouble. The full, known strength of the material can be employed safely in calculating the design of the structure.

Whether your product be a skyscraper or an electric iron, parts joined by fasteners are DEPENDABLE, SECURE, ECONOMICAL.

AMERICAN INSTITUTE of BOLT, NUT and RIVET MANUFACTURERS

1550 HANNA BUILDING, CLEVELAND 15, OHIO

MR. ROADBUILDER...
HERE'S YOUR 1 MAN MIXING CREW

THE SELF-PROPELLED
WOOD ROADMIXER
MODEL 36

This complete traveling mixing plant is made to order for detours, access roads, patch work, shoulders, and general maintenance. Self-propelled, one-man operated, and maneuverable as a motor patrol, it finishes one job and is off to the next one at 15 miles an hour—*under its own power.* Saves time—saves manpower—saves equipment.

Using local or imported materials, the Wood Roadmixer Model 36 handles up to 4 cu. ft. windrows and produces 100 to 150 tons of ready-to-spread mix per hour.

If you are a contractor or a state, county, or municipal engineer, you can use this "One-Man Mixing Crew." Write today for Bulletin 36.

ROADBUILDING
WOOD MANUFACTURING CO.
EQUIPMENT

BOX 620, 6900 TUJUNGA AVENUE • NORTH HOLLYWOOD, CALIFORNIA

GUNITE
PNEUMATICALLY PLACED CONCRETE
DENSE · DURABLE · HIGH STRENGTH
for
Restoring Disintegrated Concrete
Dam, Dock and Bridge Repairs
Steel Encasement and Fireproofing
Sewer, Water Pipe and Penstock Linings
Stack and Bunker Linings
Wood Pile Casings—Pressure Grouting
Prestressed Tanks and Silos
Get in touch with us for engineering data and estimates
GUNITE CONSTRUCTION CORPORATION
420 LEXINGTON AVE., NEW YORK 17, N.Y.
MUrray Hill 3-7699

DRILLING
ANYWHERE
We look
into
the earth
PENNSYLVANIA
DRILLING COMPANY
PITTSBURGH, PA.

of wire rope in the Chicago district office.

THE CALCIUM CHLORIDE ASSOCIATION announces the moving of its offices from the Penobscot Bldg., Detroit, to La Salle Bldg., 1028 Connecticut Ave., N. W., Washington 6, D. C.

SILVERCOTE PRODUCTS CO., Chicago, has appointed The Richkraft Co., Chicago, as sole distributor of Silvercote reflective insulation papers in the building and construction fields. Distribution will be handled through The Richkraft Co.'s national sales organization as a companion product with Richkraft building papers, Richkure concrete curing compounds, and Richlume waterproof, insulating roof coating.

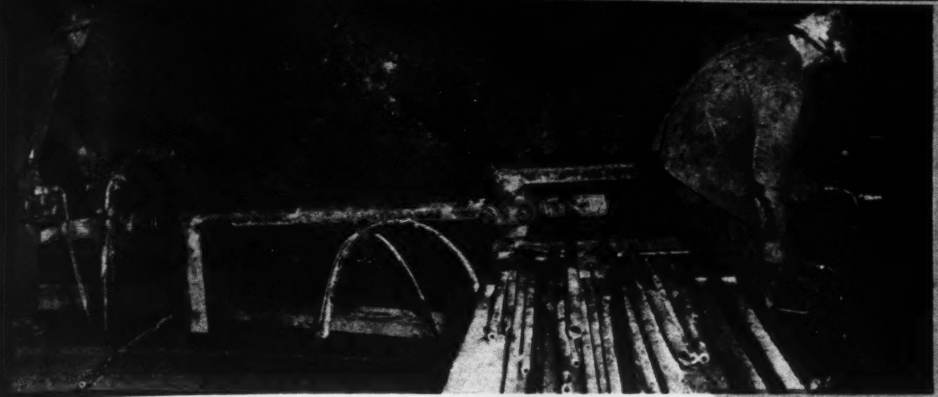
GEORGE P. TORRENCE, executive vice-president of Link-Belt Company since July 1, 1946, has become president of the company, succeeding William C. Carter. In addition to his experience with Link-Belt Co., Mr. Torrence was general manager of Rayon Machinery Corp., from 1936 to 1944, and president of Cleveland Pneumatic Tool Co. from 1944 to 1946. His experience with Link-Belt dates back to 1911.

THE IDAHO PORTLAND CEMENT CO., located at Inkom, Ida., and only producer in the state, will soon double its 1,200,000 sacks per year capacity. Plans for expansion are nearly complete with work expected to get under way as soon as machinery is available.

A complete new setup in the manufacture of its diesel engines is announced by LISTER-BLACKSTONE, INC., Milwaukee 3, Wis. All production has been moved to a new modern plant equipped with the most up-to-date tools and machines. There will be almost complete concentration on the production of straight diesel engines. A modern parts department has been established at 1568 W. Pierce St., Milwaukee and the office is at 740 N. Plankington Ave., Milwaukee 3, Wis.

JULIEN R. STEELMAN, Koehring Co., Milwaukee, Wis., was elected chairman of the Mixer Manufacturers' Bureau for 1947 to succeed G. K. Viall, Chain Belt Co.

The appointment of HOMER L. BAKER as sales manager of the Louisville Cement Co. (manufacturers of Brixment and Speed portland cement) has just been announced. Joining the Louisville Cement Co. in 1927, he was southeastern sales representative for thirteen years. In 1940 Mr. Baker was brought into the home office at Louisville to become assistant sales manager.



ER STREAK CADMIUM PLATED ROCK DRILLS

Give greater drilling speed . . . have longer life. Better Lubrication is possible, preventing rucking.

Cadmium plated rock drills are run in more accurately as the cadmium has a burnishing and lubricating effect, permitting super-smooth finishes on cylinder and piston. Closer tolerances assure more power behind every stroke . . . greater impact on the steel . . . more footage!

le cores are necessary to plan accurately for many jobs. You'll
e analyses with Sullivan Core Drills or Core Drilling by contract.

The Sullivan Series 80 has the automatic "Econo-Miser" load control—delivers 60 to 630 CFM from an extremely compact, 2 stage portable compressor—either gasoline or diesel driven.

A fast, powerful feed in three model sizes enables Sullivan Wagon Drills to give more footage per shift. Positive locking brakes, quick-set up and easy manoeuverability are other major features.

LIVAN TEAMWORK
EPS COSTS DOWN

**livan equipment works to-
her with a smooth, steady
iciency that results in in-
ased production and low-
d operating costs. Less
or, less maintenance and
s lost time add up to sav-
s that assure profits.**

Consult a Joy Engineer

SULLIVAN DIVISION

JOY Manufacturing Company

General Offices: Henry W. Oliver Building, Pittsburgh, Pa.

W&D C697

It takes
ALL THREE

for a top-flight job

Contrary to the suggestion implied by its corporate name, the Virginia Engineering Company does not offer a creative engineering or architectural service. These, in its opinion, are functions which properly lie within the province of others.

Instead, they pride themselves in a complete *construction* service which in breadth, scope and thoroughness of operations is second to none in the industry.

Only in this manner, it is believed, can the Owner's interests be served to the best advantage—through the combined efforts of Architect, Engineer *and* Contractor mutually striving for that rarity . . . the *perfect* job.

CHALLENGE IN A STAMP

We've prepared a new booklet which briefly thumbnails the 31-year record of this company; we'd be delighted to mail you a copy, if requested on your firm's letterhead.

VIRGINIA ENGINEERING
COMPANY, INC.
NEWPORT NEWS, VA. — MIAMI, FLA.

BUILDING · HIGHWAY &
HEAVY CONSTRUCTION
MECHANICAL · ELECTRICAL · UTILITIES

Contractors to American Industry
WE BUILD TO YOUR DESIGN

K. V. (Ken) Turner has been appointed assistant sales manager of LaPlant-Choate Manufacturing Co., Inc. of Cedar Rapids, Iowa. He started work for LaPlant-Choate as a blueprint clerk in the engineering department in 1938 and since then his experience has included service work, export sales, field engineering research, and district sales representative in northeastern United States.

Appointment of **Wilson A. Wright** as manager of sheet and strip sales of Republic Steel Corp. has been announced. He succeeds John W. Carpenter who has resigned due to ill health. Mr. Wright was first employed by Republic in Youngstown in 1930.

A **FIVE-YEAR RESEARCH PROJECT** to promote safe, economic and efficient highway transportation has entered its initial phase during the current school year at the University of Wisconsin College of Engineering. The project, supported by a grant accepted in 1945 from The Four Wheel Drive Auto Co., is under the direction of Archie H. Easton. Primary objectives are to make basic studies of truck and highway design for safety, economy and efficiency; to compare four-wheel drive trucks with single-axle drive trucks through experimental tests; to provide advanced study in the fundamentals and techniques of truck and highway design and to make other miscellaneous studies.

Allied Steel Products, Inc., Cleveland, Ohio, announces the appointment of John G. Fitzpatrick, Indianapolis, as direct factory agent in Ohio, Indiana, Illinois and Michigan. The company manufactures Bulldog grip-lug, Mango repointer bars, "Excelloy" hard surfacing materials, etc.

A new company, **Tractomotive Corp.**, has been formed to manufacture equipment for industrial wheel and crawler tractors. V. M. Dobeus, formerly chief engineer, Springfield works, tractor division of Allis Chalmers Co., is president. Paul B. Cochran, formerly general manager of Buckeye Traction Ditcher Co. is vice president and treasurer. The plant and engineering department now operate at Findlay, Ohio.

Charles F. Codrington has been promoted from assistant to the manager to sales manager of the blower and compressor department of the Allis-Chalmers Mfg. Co., Milwaukee, Wis. Mr. Codrington joined Allis-Chalmers' graduate training course in 1930 and served in the engine and condenser department for some time before becoming associated with the blower and compressor department in 1935.

Remember
IT'S THE SCRAPER
THAT CARRIES
THE PAYLOAD!

. . . AND COMPETITIVE TESTS PROVE THAT LaPLANT-CHOATE SCRAPERS DO THE BEST JOB UNDER THE MOST CONDITIONS!

In the final analysis, *any make* of crawler tractor with sufficient horse-power will do a reasonably good job of handling a scraper. But when it comes to selecting *the right scraper*, it's an entirely different story. Some scraper outfits get heaping loads in double-quick time. Others take much longer — even with the aid of a pusher. Some will dump or carry a smooth spread in high gear, while others are slow and uncertain—especially in wet or bulky materials. Some scrapers make efficient use of tractor power — others burn it up by lugging around "an extra yard of deadweight" that is strictly an extra cost item. The point is—regardless of what tractor you use, there's *a whale of a difference in scraper performance.* And that difference in the scraper alone can have an important bearing on your stripping or material handling costs. That's why more and more smart operators are picking up whatever tractors they can get—and standing pat on LaPlant-Choate Positive Forced Ejection Scrapers. Why LPC? Because competitive tests prove that under the varying conditions of scraper operation, La-Plant-Choate's improved rigs consistently deliver *highest average production at lowest over-all cost.* Just ask any recent LaPlant-Choate owner. LaPlant-Choate Manufacturing Co. Inc., Cedar Rapids, Iowa; 1022 77th Ave., Oakland, Calif.

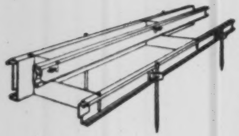
LaPLANT CHOATE

Positive FORCED EJECTION SCRAPERS

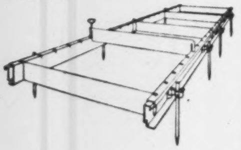
FIRST in value
because they're
FIRST in
performance

STEEL FORMS

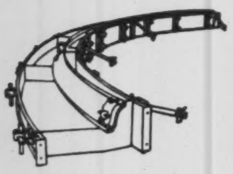
Curb Forms...Sections 10' long for either straight face or battered face construction. Steel forms for all special concrete curbs.



Combined Curb and Gutter Forms...Each 10' section consists of 1 each of back curb form, front gutter form and face curb form, also 2 each of face curb form supports, round stakes for back form and round stakes for gutter form.

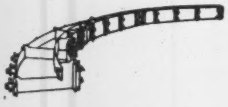


Sidewalk Forms...10' sections, slotted 12" for division plates, which are removed without disturbing side forms after concrete takes its initial set.



Rigid Radius Forms...Used for building concrete curbs or curb and gutters when all intersections or corners must match. Heltzel forms made in sets to form a specified radius.

Flexible Forms...Used when building radius curbs, curb and gutters or sidewalks where the radius is subject to frequent change or for serpentine work in park areas.



CONCENTRATED Engineering IN CONCRETE CONSTRUCTION

Heltzel
BUILDS IT BETTER

BINS Portable and Stationary
CEMENT BINS Portable and Stationary
CENTRAL MIXING PLANTS
BATCHERS (for batch trucks or truck mixers with automatic dial or beam scale)
BITUMINOUS PAVING FORMS
ROAD FORMS (with lip curb and integral curb attachments)
CURB FORMS
CURB AND GUTTER FORMS
SIDEWALK FORMS
SEWER AND TUNNEL FORMS
CONCRETE BUCKETS
SUBGRADE TESTERS
SUBGRADE PLANERS
TOOL BOXES
FINISHING TOOLS FOR CONCRETE ROADS

Heltzel Steel Form & Iron Company, Warren, Ohio

SEND ME STEEL FORM CATALOGS:

☐ B-19 Steel Highway and Airport Forms
☐ B-19A Steel Dual Duty Airport Forms
☐ A-20 Steel Forms for Curbs or Curb and Gutters or Sidewalks.

Name____________________________
Address__________________________
____
(Type of construction usually engaged in)

HELTZEL STEEL FORM & IRON CO.
WARREN, OHIO · U. S. A.

Manufacturers' Publications

Trailer Accessories — (16-p. bulletin) Describes and pictures air brakes, vacuum brakes, couplers, safety tanks, sander, elevating endgate, winch, lights and safety equipment, horns, jacks.—*Fruehauf Trailer Co., Detroit 32, Mich.*

Power Plant—(20-p. booklet) Describes "package-type" steam turbine generator power plant. Ten functional units into which electrical and mechanical equipment of plant is coordinated are described and pictured.—*Worthington Pump & Machinery Corp., Harrison, N. J.*

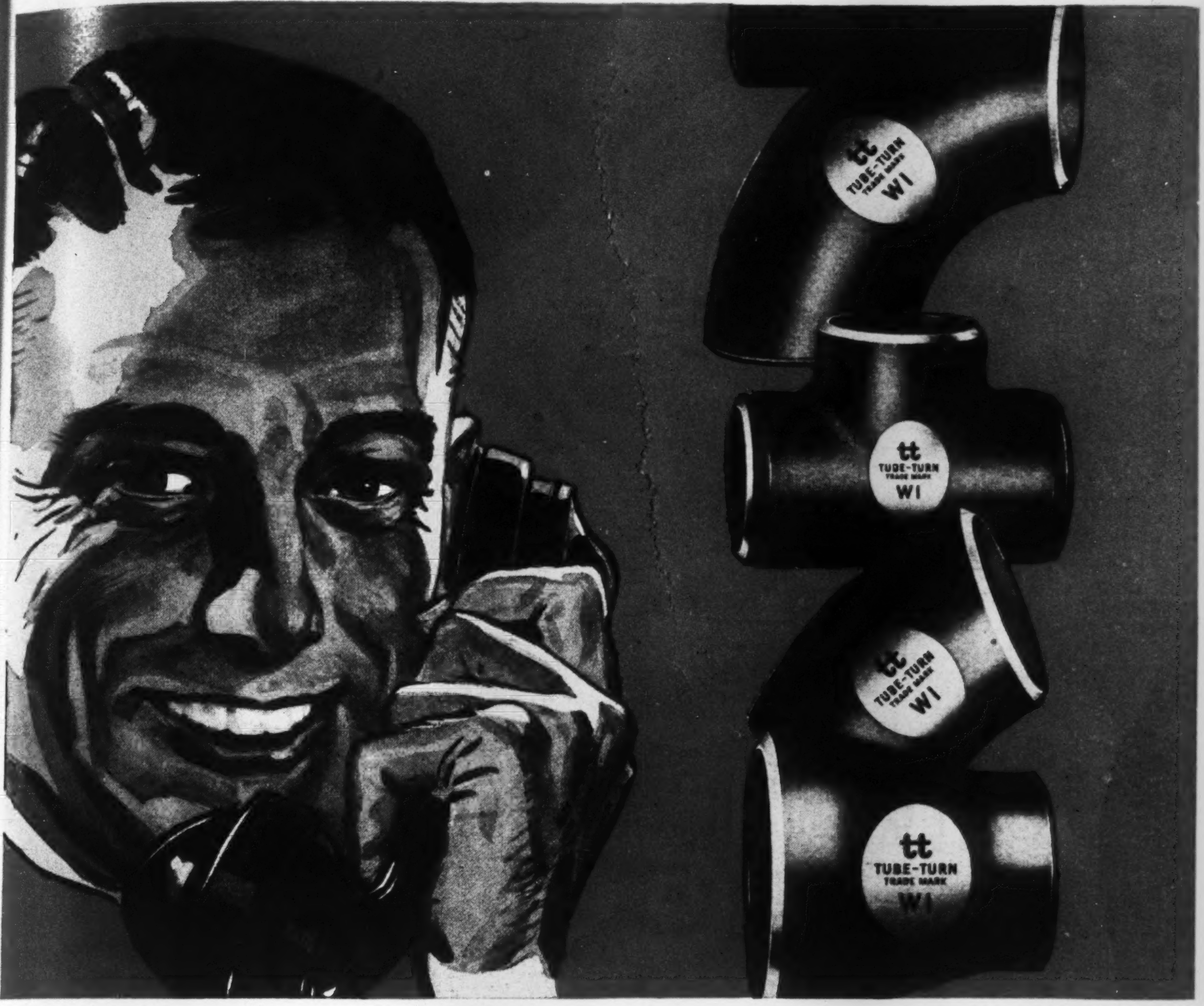
Compressors—(24-p. booklet) Describes single horizontal air and gas compressors. — *Worthington Pump & Machinery Corp., Harrison, N. J.*

On-and-Off Track Equipment — (4-p. folder) Describes auto-railer, dual-purpose vehicle for operation on railroad tracks and highways. It is available as chassis on which various types of bodies can be mounted.—*Evans Products Co., Detroit, Mich.*

Engines—(12-p. catalog) Features Ford-built engines for industrial and marine use. Specifications and dimensions are given. It fully describes 100-hp. V8, 90-hp. 6-cylinder, and 40-hp. 4-cylinder engines. Power curves show recommended speed range for continuous operations. — *Industrial & Marine Engine Division, Ford Motor Co., 3000 Schaefer Rd., Dearborn, Mich.*

Wire Ropes—(Pocket-size reference manual and catalog) Covers uses and selection of wire ropes for mining and is also applicable to construction. It gives fundamental engineering data on wire ropes and general principles governing their use. Several valuable tables and illustrations are included.—*Rochester Ropes, Culpeper, Va.*

Thermometers and Pressure Gauges —(20-p. catalog) Describes vapor, gas and mercury-actuated thermometers and pressure gauges. Large cutaway illustration features design improvements found in Brown products, with each part clearly labelled for easy identification. Bulbs, charts and interchangeable cases are fully treated, as are operating features of instruments.—*Brown Instrument Co., Wayne & Roberts Aves., Philadelphia 44, Pa.*



"Sure we've got Wrought Iron Welding Fittings!"

WHEN you need wrought iron welding fittings *you really need 'em!* A good way of getting them is to get the Tube Turns distributor on the phone.

He handles the most complete line of welding fittings on the market, represents the one source of supply on which you can depend for all welding fitting requirements.

Tube-Turn wrought iron welding fittings are a standard part of the line as well as stainless steel, copper, aluminum, monel metal, inconel, nickel, carbon moly, chrome moly, brass. Tube-Turn welding fittings in these metals are available in all necessary weights, in a wide range of analyses, types, and sizes. The complete line of Tube-Turn welding fittings and flanges covers more than 4,000 items. Many of these are in stock with foresighted Tube Turns distributors, in every strategic industrial center, who built up a supply when this was still readily possible.

Write for the name of your nearest Tube Turns distributor and facts about how *the fittings that become part of the piping* serve others in your industry.

TUBE TURNS (Inc.) LOUISVILLE 1, KENTUCKY.
District Offices at New York, Washington, D.C., Philadelphia, Pittsburgh, Cleveland, Detroit, Chicago, Houston, San Francisco, Los Angeles.

TUBE-TURN TRADE MARK **tt** ***Welding Fittings and Flanges***

ONE SOURCE OF SUPPLY FOR ALL WELDING FITTING REQUIREMENTS

PIONEER AND PACEMAKER

. . . in building high-speed diesels

. . . in placing value before volume

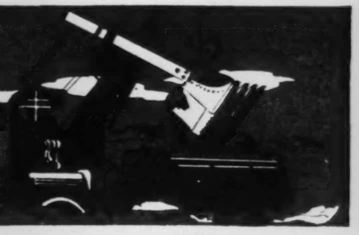
. . . in developing a complete parts-service network

CUMMINS DIESELS

SINCE 1919 . PIONEER OF PROFITABLE POWER THROUGH HIGH SPEED DIESELS

CUMMINS ENGINE COMPANY, INC. · COLUMBUS, INDIANA

STANDARD ENGINEERS NOTEBOOK



CALOL

RPM

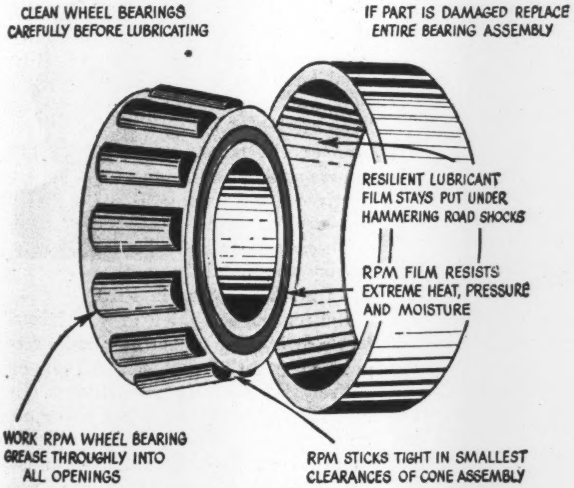
Heat-resistant grease stays in wheel bearings

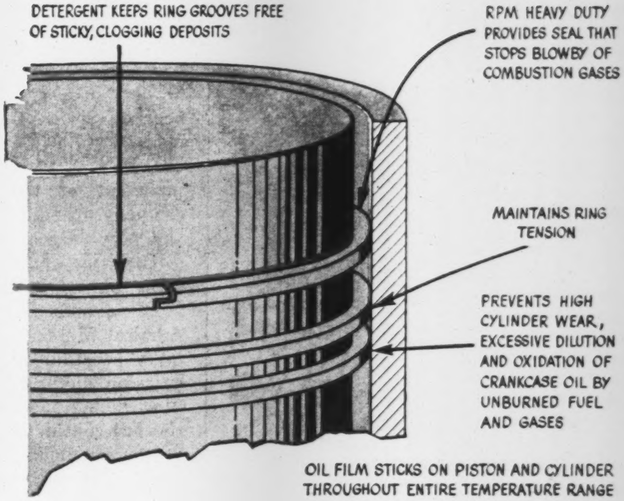
RPM Wheel Bearing Grease is specially made for all types of wheel bearings. Because it withstands extreme heat, it won't melt and throw out even in hard service. This prevents lubricant from working onto brake shoes and keeps bearings from becoming dry. Where necessary, extra grease can be packed in hubs, thus assuring adequate lubrication at all times.

The tough, resilient film which RPM Wheel Bearing Grease spreads over bearings, won't break down under extreme pressure or jolts and shocks. It resists water and seals out dust and dirt.

Truck and bus manufacturers recommend using extra care in lubricating, cleaning, and adjusting wheel bearings.

Handy guides that assure this are the free Standard booklets, "How to Service Wheel Bearings." There's one for light equipment and one for heavy equipment. Send for your copies.


CLEAN WHEEL BEARINGS CAREFULLY BEFORE LUBRICATING
IF PART IS DAMAGED REPLACE ENTIRE BEARING ASSEMBLY
RESILIENT LUBRICANT FILM STAYS PUT UNDER HAMMERING ROAD SHOCKS
RPM FILM RESISTS EXTREME HEAT, PRESSURE AND MOISTURE
WORK RPM WHEEL BEARING GREASE THROUGHLY INTO ALL OPENINGS
RPM STICKS TIGHT IN SMALLEST CLEARANCES OF CONE ASSEMBLY


DETERGENT KEEPS RING GROOVES FREE OF STICKY, CLOGGING DEPOSITS
RPM HEAVY DUTY PROVIDES SEAL THAT STOPS BLOWBY OF COMBUSTION GASES
MAINTAINS RING TENSION
PREVENTS HIGH CYLINDER WEAR, EXCESSIVE DILUTION AND OXIDATION OF CRANKCASE OIL BY UNBURNED FUEL AND GASES
OIL FILM STICKS ON PISTON AND CYLINDER THROUGHOUT ENTIRE TEMPERATURE RANGE

Heavy-duty motor oil reduces cylinder wear

Many fleet operators have eliminated stuck rings, blow-by and excessive cylinder wear by using RPM Heavy Duty Motor Oil.

This special heavy duty oil contains patented additives which remove sticky gum, carbon and lacquer from rings and ring grooves, keeping rings free so they can expand fully. With rings expanded, the tough lubricant film of RPM Heavy Duty Motor Oil forms a seal between rings and cylinder which prevents the force of combustion from driving gases and fuels down the walls.

RPM Heavy Duty Motor Oil sticks to metal at all operating temperatures. This assures unsurpassed lubrication at all times on surfaces of cylinders, pistons and rings, reducing wear to a minimum.

RPM Heavy Duty Motor Oil will resist sludge formation even in coldest operations, will not foam or corrode bearing metals.

For additional information and the name of your nearest Distributor, write Standard of California, 225 Bush Street, San Francisco 20, Calif.; The California Oil Company, 30 Rockefeller Plaza, New York 20, N. Y.; The California Company, 17th and Stout Streets, Denver 1, Col.; Standard Oil Company of Texas, El Paso, Texas.

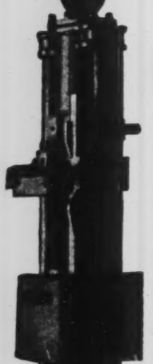
FOR EVERY NEED A STANDARD OF CALIFORNIA JOB-PROVED PRODUCT

THRIVING on the TOUGH ONES

WARRINGTON-VULCAN

Single-Acting Steam

PILE HAMMERS



It takes the right equipment to thrive on the tough ones — whether they're tin cans or pile driving jobs. And in pile driving, the right equipment is the Single-Acting Warrington-Vulcan.

It gets results operating at a medium steam pressure to deliver a moderate frequency of effective, low velocity blows from a relatively heavy ram. It sinks wood, concrete or steel piles with speed and saving. Simplicity of design and rugged strength minimize operating, maintenance and mechanical costs. With its rapid, regular and continuous action, this rugged pile driver has been thriving on the toughest jobs since 1887.

We'll gladly furnish full details. Write today.

VULCAN IRON WORKS
Since 1852
331 North Bell Avenue
Chicago 12 --- Illinois

MEN AND JOBS

Ben Moreell, president of the Turner Construction Co. has announced the appointment of **F. E. Schilling,** of New York, as vice-president in charge of labor relations. Mr. Schilling went with the Turner 39 years ago after being graduated from the Thayer School of Engineering at Dartmouth in 1908. He has been a vice-president of the company for many years and previously had been a general superintendent of construction and executive in charge of many important building projects

In announcing the appointment Admiral Moreell said, "Relations with labor constitute a problem of ever increasing importance to any large employer. We intend to give the subject the full consideration which it deserves as one of our major problems of operation."

John L. Geagin, district engineer for the Portland Cement Association of Chicago, will head the Memphis, Tenn., branch of that company with offices at 22 North Front St. He will have charge of all activities in Arkansas and Tennessee. A graduate of Alabama Polytechnic Institute, he was formerly employed in architectural work by the War Department.

Guy B. Smith, who has been acting city engineer of Little Rock, Ark., since last May, has been certified to the post by the Civil Service Commission of the state.

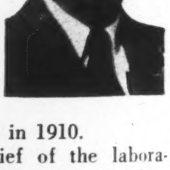
Marvin F. Johnson, Pikeville, Ky., has resigned as engineer on special design problems in the Kentucky highway department to join the War Department's engineering staff at Langley Field, Va.

L. C. Hanks, senior highway inspector for North Carolina, who was granted a leave of absence to participate in war work, has returned to his position in Division Eight.

Robert Emmett Baker has resigned as secretary-treasurer of the Arthur G. McKee & Co., Cleveland, Ohio, engineers and contractors after 40 years of continuous service with the company and its predecessors. He has been a director, secretary, and treasurer. He became a partner of Arthur G. McKee soon after the latter opened an engineering office in Cleveland in 1905. Mr. Baker will continue as a director and a member of the advisory committee. **H. R. Moorhouse** has been elected secretary and **James Krumhansl** has been named treasurer of the McKee firm, replacing Baker. Moorhouse has been Baker's assistant since 1929 and in recent years has been assistant secretary of the company. Krumhansl has been with the firm since 1913.

Commander Bradford N. Clark, CEC., U.S.N.R., recently placed on the inactive list, has been named by Eggers & Higgins, New York City architects, as manager of the construction division. He returns to civilian life after nearly four years in the U. S. Navy. He was graduated from Pratt Institute and the New York University college of engineering. Identified in civilian life for some years with community engineering projects in Westchester County, N. Y., Commander Clark, prior to his Navy service, was on the Engineering Staff, U. S. Army, in a consultant capacity identified with civil engineering aspects of the development of Camp Kilmer, Camp Shanks and the U. S. Military Academy's Stewart Field near West Point.

Thomas R. C. Wilson, for the past 36 years one of the small group of Forest Products Laboratory scientists who laid the technical foundations for many modern engineering advances in wood construction and use, retired Dec. 31. He had been on the laboratory staff practically continuously since the federal wood research agency was founded in Madison, Wis., in 1910.



Retirement as chief of the laboratory's division of timber mechanics does not mean that Mr. Wilson will give up entirely his professional activities. He will remain for a few weeks to prepare an important report. After that he plans to continue to make use of his broad engineering experience with wood structures as a consultant to private wood fabricating and manufacturing firms. He will specialize in glued laminated construction of the type now widely used in auditoriums, churches, factories, and other large buildings.

Mr. Wilson came to the Laboratory

in June, 1910. He left to accept another position in February, 1917, but was recalled in May of that year to help guide the efforts of the laboratory in World War I and has remained ever since. A graduate of Purdue University with the class of 1909, he taught engineering courses there for a year before joining the laboratory.

R. P. A. Johnson, another veteran engineer of the Laboratory staff, will succeed Mr. Wilson as Chief of the Division of Timber Mechanics.

Philip S. Davy, a former lieutenant colonel in the Corps of Engineers, has returned to consulting work with the Davy Engineering Co. of La Crosse, Wis.

R. K. Greene, president of the Association of County Commissioners of Alabama, has announced appointment of the following to the 7-man committee of county engineers to confer with the State Highway Department on standards of road construction: Engineers **Melvin Holt,** Limestone County; **V. H. Padgett,** St. Clair County; **L. J. Moore,** Dallas County; **J. D. Bullington,** Lauderdale County; **P. M. Stephenson,** Baldwin County; **W. B. McDonald,** Covington County; and **R. L. Williams,** who will represent Geneva County.

Appointment of **Joel D. Feagin** to the city engineering staff of Montgomery, Ala., has been announced by the city commission. He will expedite street paving. He has just been released from the Army where he served as a lieutenant colonel in the Corps of Engineers. Before joining the Army, he was a member of the state highway department and had been a consulting engineer for several towns and cities in Alabama.

E. M. Anderson, Urbana, Ill., firm member of Wilson and Anderson, consulting engineer, Champaign, Ill., has been appointed to serve as engineer-manager of the Urbana-Champaign Sanitary District while Walter M. Kunsch is on leave-of-absence because of illness.

Luke H. Sperry, a member of the board of directors and director of engineering for Hercules Powder Co., has retired. **Ernest S. Wilson,** chief engineer, has become director of the engineering department, and **Ray N. Wheelock** assistant director. The retiring director has been a resident of Wilmington, Del., since 1939 when he was appointed to the position of chief engineer.

Stephen C. Casteel, resident engineer with the East St. Louis and Interurban

"What... you want to steal my FRIDEN?"

So you noticed there is *such* a difference in calculators. Yes, that's exactly what I told the boss... order a Friden for me, with all its exclusive ***fully automatic*** features. The thing that really surprised me was how ***easy*** they are to operate... after less than ***15 minutes instruction*** I was able to breeze thru my figure problems. If you like my Friden, ask the boss to order one for you NOW. New cars are not immediately available... but Fridens are worth waiting for, too! Just have him telephone the local Friden Representative... today."

Friden Mechanical and Instructional Service is available in approximately 250 Company Controlled Sales Agencies throughout the United States and Canada.

FRIDEN

FRIDEN CALCULATING MACHINE CO., INC.

HOME OFFICE AND PLANT · SAN LEANDRO, CALIFORNIA, U. S. A. · SALES AND SERVICE THROUGHOUT THE WORLD

KINNEY
BITUMINOUS DISTRIBUTORS
EXACT CONTROL MEANS FAST, UNIFORM SPRAYING WITHOUT WASTE

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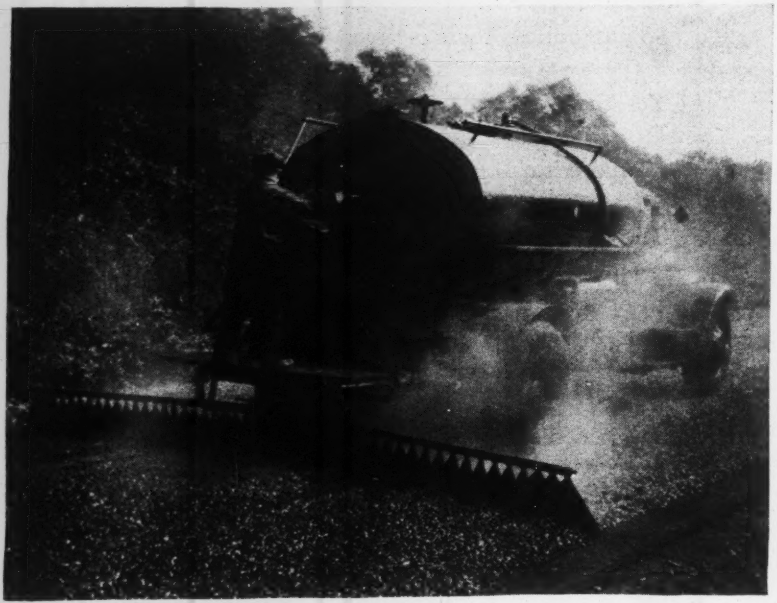

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Water Co., East St. Louis, Ill., since 1941, has been appointed assistant manager, replacing **F. P. Stradling**, recently named manager of the Bristol County, R. I., Water Co. Both companies are under the management of the American Water Works and Electric Co., Inc. Mr. Casteel's engineering and construction work in water supply has taken him over the United States, and to Canada and Cuba. **William R. Mize,** chief engineer of the Alton Water Co. since 1941, has been appointed chief engineer of the East St. Louis and Interurban Co., effective Feb. 1, to replace Casteel. Before 1941, Mize was chief engineer for the Marion Water Co., Marion, Ohio. He will be in charge of the company's 11 stations in the area.

James R. Daugherty has opened offices as a consulting engineer in Portland, Ore., at 4636 N. E. Garfield Ave. He is a civil and sanitary engineer who most recently supervised a large concrete pipe culvert jacking operation for Reno, Nev.

W. H. Stewart, formerly with the Oregon Highway Department, has been named city engineer at Dallas, Ore.

P. R. Nalder, assistant office engineer for the Columbia Basin project at Coulee Dam, Wash., since his return from AAF service, has been assigned to the Washington, D. C., offices of the Bureau of Reclamation as chief of the division of design and construction.

Robert H. Hayes is now chief, Engineering Division, U. S. Engineer Office, Garrison district, Bismarck, N. D., in charge of design for the Garrison dam and reservoir project. He was chief, Engineering Division, U. S. Engineer Office, Providence, R. I. He is a graduate of the University of North Carolina, B.S.C.E., 1929. Previous connections have been with the **N. Y.** Air Terminals, Inc., Stone & Webster, and several U. S. Engineer offices, including St. Louis, Mo., Massena, N. Y., Wright Field, Ohio, and Norfolk, Va.

Burns & McDonnell Engineering Co., Kansas City, Mo., in its 49th year of consulting engineering work, has enlarged its membership from four—**R. E. McDonnell, C. A. Smith, R. L. Baldwin,** and **R. H. McDonnell**—to eight. The new members selected from the senior associate engineers are:

Arthur F. Hartung, electrical engineer, graduate of the University of Kansas, who joined Burns 18 years ago and specializes in electrical and power design.

Russell G. Kincaid, civil and hydraulic engineer, graduate of the Uni-

Welded Steel Cages Tie-in Columns and Roof

WELDED steel cages are used for tie-in between tubular columns and the reinforcing structure of a roof in a building addition erected in Cleveland, Ohio. Architects: Cutting & Ciresi.

The reinforced concrete structure is 60′ x 182′ with a wing 105′ wide. So that another floor may be added later, the roof is heavily reinforced to take 400 lbs. per sq. inch.

Details of the welded steel cage and the top of the tubular column are sketched in Fig. 1. The cages are made of ¾″ round reinforcing bars, formed into rectangles and butt welded. These rectangles are tied together with ¼″ tie rods, tack welded to the bars.

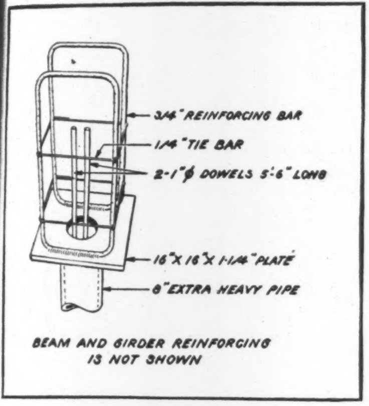


FIG. 1

Fig. 2 shows how the steel cages are welded, on both sides of each leg, to the top plate of each column by a 4″ fillet weld using 3/16″ "Fleetweld 5" electrode.

The tubular columns are 8″ diameter, extra-heavy pipe. Plates measuring 16″ x 16″ x 1¼″ are shop-welded to the column ends with a ¼″ fillet all around.

The building has ten columns 17′-10″ long and two which are 21′-8″ long.

Fig. 3 shows one column and steel cage, and the framework used to support forms for concrete girders, beams and floor slabs.

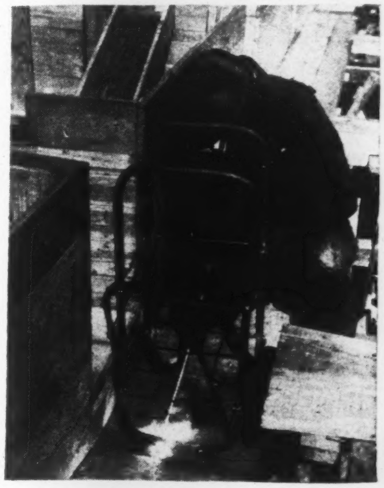


FIG. 2

Fig. 4 shows roof during a later stage of construction with reinforcing bars for girders and beams in place, ready for placing of concrete.

The reinforced concrete girders are 28″ deep and are haunched down at the columns. Reinforcing bars in girders are 1⅛″ square and those in the beams are 1″ round. Strap iron frame shown in center of picture will have anchor bolts through the four holes for future second-floor column.

The Lincoln Electric Company for years has been publishing a series of Studies in Structural Arc Welding. These may be obtained by writing to THE LINCOLN ELECTRIC COMPANY, Dept. 251, Cleveland 1, Ohio.

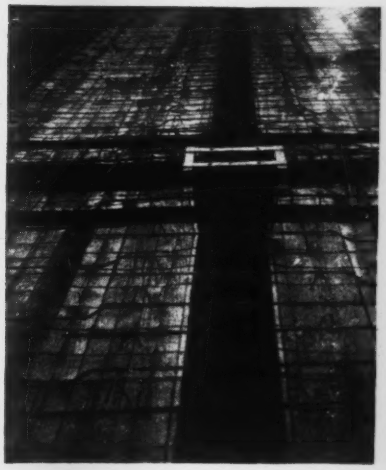
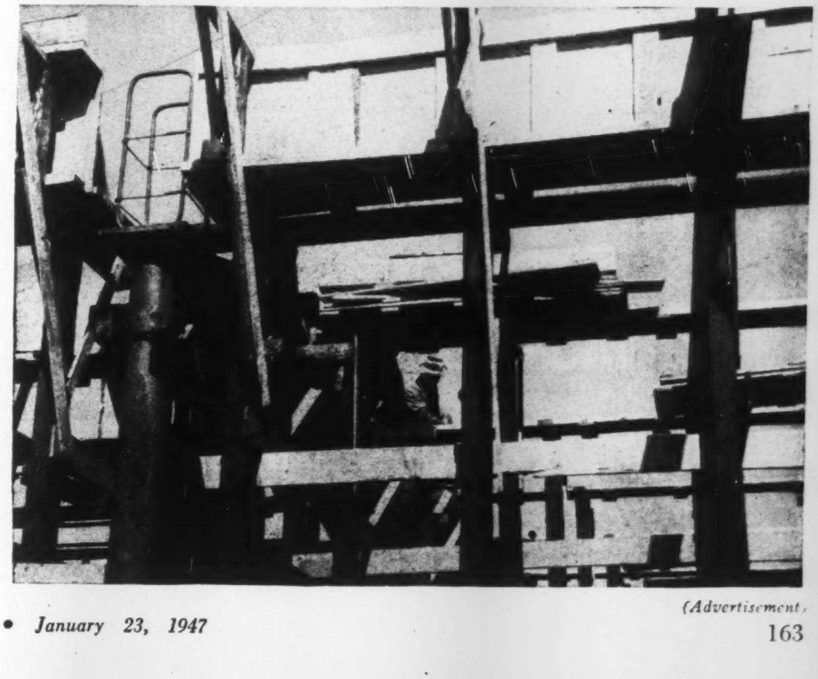


FIG. 4

FIG. 3



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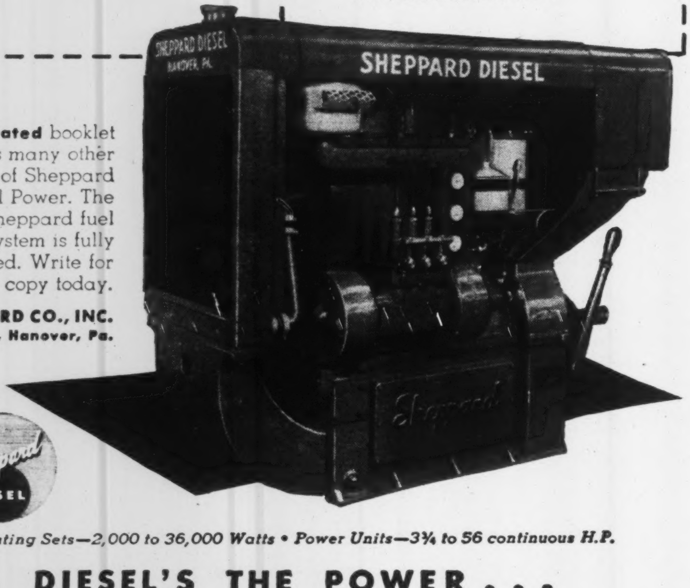

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versity of Missouri, who has been with the firm for 20 years and specializes in hydraulic work.

C. Kelsey Mathews, civil engineer, graduate of the University of Kansas, who served three years as instructor in civil engineering at the University of Illinois, went to the firm 24 years ago, and specializes in appraisals and sanitary works.

Earl J. Thomson, electrical engineer, graduate of Manitoba and Marquette universities, who served four years as acting and assistant city engineer at Moose Jaw, Sask., went to the firm 11 years ago and specializes in water works, sewage treatment, and power plants.

Albert W. Gray, assistant to the president of the Hartford Electric Light Co. for the last 21 years, and in his earlier career active in civil engineering work for the Massachusetts Highway Commission; as street commissioner of Colorado Springs, Colo., and construction manager on the Glenwood and Boulder hydro-electric developments of the Colorado Power Co., has retired from active service. Before joining the Hartford company Mr. Gray was a construction superintendent for the Stone & Webster Engineering Corp., Boston, and later an executive in several Connecticut industrial plants and for a time chairman of the board of the Hartford Electric Steel Corp.

Lyle Fuller, who received his engineering education at the University of Wisconsin and who was engineer for the Marathon County, Wis., highway department for the last ten years, has been appointed acting county highway commissioner.

H. E. Horner, supervisor of airports at the Chicago regional office of the CAA, has resigned to become a member of Foth & Porath, Inc., consulting engineers of Green Bay, Wis. The name of the firm will be changed to Foth, Porath & Horner, Inc. Mr. Horner was city engineer of Peoria, Ill., for four years and for six years was a contractor in Florida.

Herman J. Eklund, Rockford, Ill., engineer and architect, has joined the staff of the Francis Engineering Co. of Rockford.

Commodore Robert C. Johnson, widely known in engineering and construction circles throughout Wisconsin before he entered the naval service, will become executive vice-president of the Siesel Construction Co. of Milwaukee on Feb. 1, following his release from active duty. He is now public works

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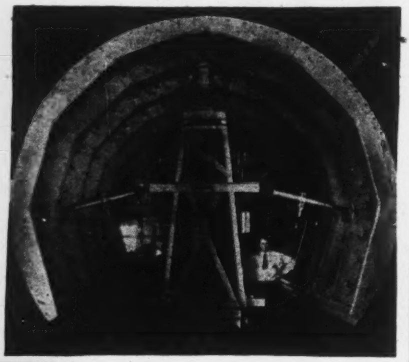

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officer at the Jacksonville, Fla., naval station.

Herbert Scott-Smith, superintendent of streets, sewers and water, Waterbury, Conn., retired on Jan. 1, after 39 years of service with the department. His duties will be taken over by **James R. McMahon,** now an assistant superintendent who becomes superintendent of streets and sewers, and by **John F. Kelly,** another assistant superintendent, who becomes superintendent of water.

W. R. Smith recently Middlesex County, Ont., engineer, has gone with Ontario's Department of Planning and Development, at Toronto.

J. Fred Offutt, veteran employee of the Baltimore County, Md., highway department, has been appointed roads engineer and head of the department by the Board of County Commissioners. Formerly engineer of plans, Mr. Offutt succeeds **G. Douglas Andrews,** who had been acting head of the highways department since the resignation of Joseph D. Thompson last June. Mr. Andrews was reappointed to the post of chief engineer of the metropolitan district.

Robert Lee Morrison, of Concord, N. C., who has been serving as district engineer of the Federal Works Agency at Knoxville, Tenn., has been named city manager of Knoxville.

Official transfer of 67 employees of the Louisville, Ky., sewer division to the new sewer board, which has taken over all sewer work, has been made. Heading the new division will be **G. R. Gregg,** who has had charge of that work and the street cleaning division. **Frank A. Nolan** was named street cleaning superintendent, and **Charles Staley,** his assistant.

Ray Widdifield has been named to succeed C. Homer Bricker as Medina County, Ohio, engineer. He has been connected with the department for nine years.

Eugene G. Funk has been named superintendent of the New London, Ohio, municipal water and sewage disposal plants.

Virgil F. Bowers has become Adams County, Ind., surveyor at Decatur, replacing **John W. Tyndall,** who will remain as Bowers' deputy.

Ralph Wolf, Columbus, has been appointed executive secretary of the Ohio Highway Department, succeeding Ralph Groves, Newark. He is a graduate of Ohio State University and before the war was employed in the city engineer's

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Back in 1897 the type of spark-ignited internal combustion engine we all take for granted today was no more than a gleam in the eye of enthusiasts. There were automobiles, of course, and tractors and portable power units of a sort, but they were clumsy and unreliable by present standards.

That was when the inventor of the first portable storage battery, Thomas Witherbee, set up shop in New York. What he made was called an "igniter" and it was, strangely enough, the lineal ancestor of today's best known *batteryless* ignition unit. In 1904 he formed the Witherbee Igniter Company and when he made a piece of equipment that developed the necessary spark *without a battery* it also was called a Witherbee Igniter. This electric igniter used an entirely different ignition method, and it could produce a strong, hot spark regardless of engine speed.

For years standard equipment on most cars and other internal combustion engines was a WICO magneto — the trade mark was taken from the initials of the original company. The business was moved to Massachusetts in 1909 and when it was reincorporated in 1920 it became the Wico Electric Company, following the trade mark.

Today WICO is the world's largest producer of magnetos exclusively, supplying many of America's largest manufacturers of farm implements, contractors' equipment, outboard motors, and large and small power units of all kinds. A well trained staff of field engineers and more than a thousand authorized service stations throughout America sell to and serve the ultimate users of these economical, reliable magnetos. Wico Electric Company, West Springfield, Massachusetts.

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office in Columbus, Ohio.

Schuyler Lee, Clyde, Ohio, has been appointed superintendent of Erie County highways, succeeding **George Weidle,** elected county commissioner in November.

Leon Smith has become Allen County (Fort Wayne), Ind., surveyor for a 4-year term, succeeding W. Carlisle Duell. **Herbert W. Henschen** is the new chief deputy surveyor. Mr. Smith formerly served as chief deputy surveyor. **Edward Neiter** has been reappointed Allen County highway superintendent for 1947. However, he has submitted his resignation, effective Feb. 1, and no action has been taken on his successor.

Engineering School News

William D. McIllvaine, Jr., has been appointed director of engineering extension services at the University of Alabama. His previous work has included a variety of engineering assignments with the Minneapolis-St. Paul Sanitary District, Minnesota State Highway Department, and the Bureau of Engineering of the City of Chicago. Mr. McIllvaine has also taught at the University of Minnesota and performed association, research, and editorial work for the American Public Works Association.

University activities with which Mr. McIllvaine will be concerned include the college grade engineering courses at the extension centers in Birmingham, Mobile, and Montgomery, specialized courses of value to industry and government, and cooperation in engineering short courses and conferences.

The Purdue University Technical Institute, operating in Indianapolis, with Merle M. McClure, district manager, has 606 students currently enrolled. Courses are given in drafting, mechanical technology, supervision of construction, the technology of structures, and plan reading.

The Cooper Union, New York City, has shifted from its own competitive entrance examinations for day engineering school applicants to the nationwide College Entrance Board Examinations for engineering schools, Edwin S. Burdell, director of The Cooper Union, has announced. Entrance will continue to be on a competitive basis, however, and those with the highest scores in the College Board tests will constitute

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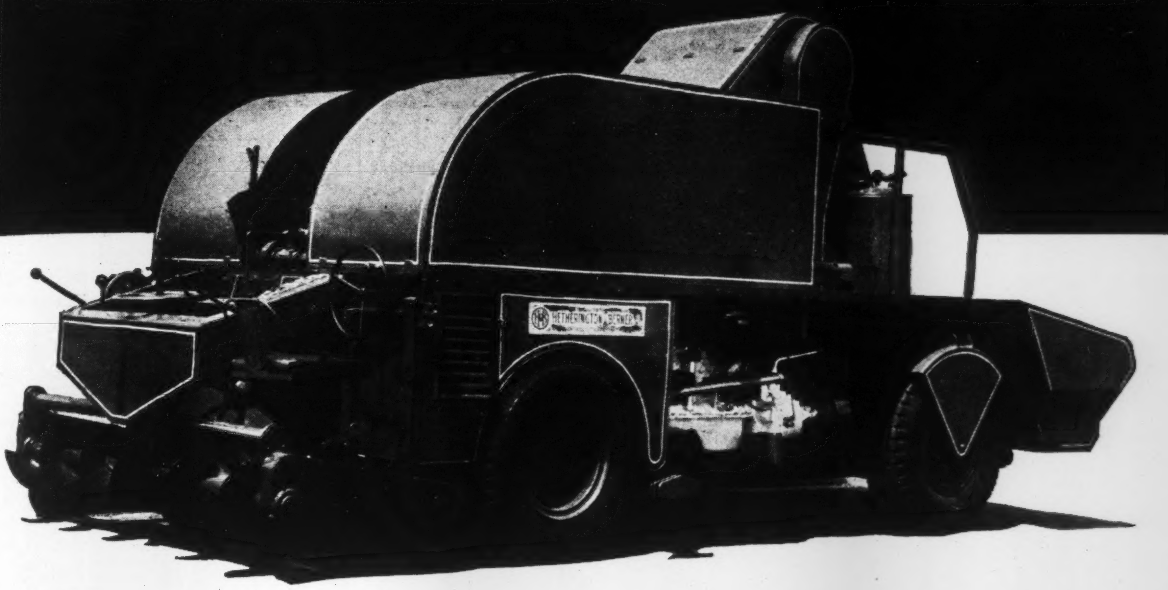

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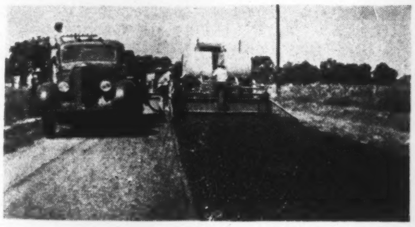

One contractor, after watching the Moto-Paver perform, said: "I've been in this business for twenty years and this is the first real improved method of doing mixed-in-place work I've seen."

The Moto-Paver mixes and paves as it goes—spreading and laying any type of mixed-in-place bituminous material to any width, thickness and crown condition desired. When the job is finished the Moto-Paver can be driven, under its own power, to the next job. Paving speed is 4 to 50 feet per minute, road travel speed up to 25 miles per hour, mixing capacity 100 to 120 tons per hour.

The Moto-Paver is especially adapted to resurfacing work on county roads and city streets, but is also highly efficient on new construction. Bulletin MP-46 will be sent on request.

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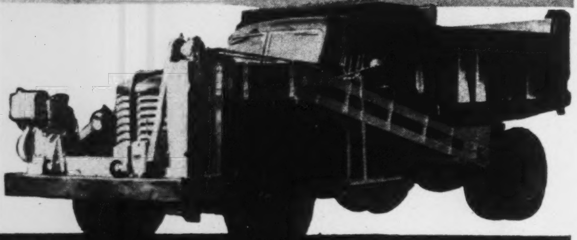

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This unique piece of equipment is a street and highway sander, designed and manufactured by Carroll Machine Works, St. Paul, Minn. Powered by a Model *AHH* single cylinder Wisconsin Air-Cooled Engine, this machine has a capacity up to 1 cu. yd. per minute, and spreads material evenly, in a full circle or directionally from 8 to 30 ft.

In this type of outdoor operation, it is vitally important, of course, that the power unit not only be of rugged, HEAVY-DUTY design and construction, but also that it be adapted to ALL-WEATHER SERVICEABILITY. These are factors that are *basic* in all Wisconsin Engines.

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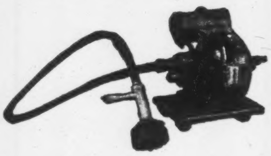

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THE CONCRETE
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the group from which the freshman class will be selected.

The college of engineering, University of Illinois, will take no new students for the summer session. Second semester classes, beginning in February have been closed to additional engineering registrants for several weeks. President George D. Stoddard says it is impossible to expand the instructional staff and the necessary facilities to care for more engineering students than those now registered at Champaign-Urbana, in the Navy Pier branch, Chicago, in the Galesburg, Ill., branch, and in about 30 Illinois high schools where freshmen students in engineering are started.

There are 1,276 veterans taking civil engineering courses and 1,362 mechanical engineering in Canadian universities.

Blake P. Van Leer, president of the Georgia School of Technology, has been elected president of the Division of Engineering and Land-Grant Colleges and Universities.

Elections and Activities

Robert E. Allen of the Univis Lens Co., was named president of the Dayton, Ohio Society of Professional Engineers Club.

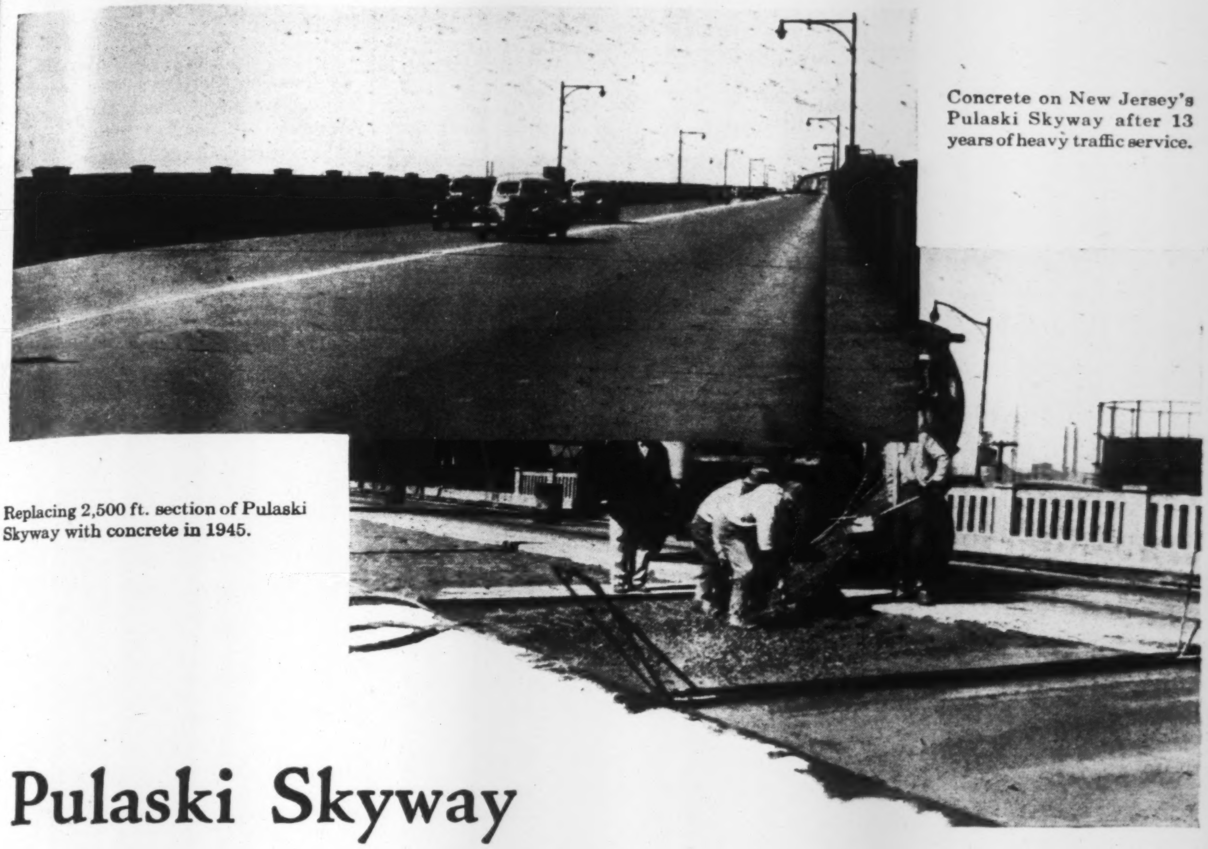
Directors elected included Harold Boyd, Sun Oil Co., and E. L. Luaces, Research and Development Corp.

Allen succeeds Leo F. Flotron of the City Engineering office as president.

Other officers include Hubert Cline, Frigidaire division, General Motors Corp., vice-president; Marvin Olsen, National Cash Register Co., treasurer and James P. Monroe, Dayton Rubber Manufacturing Co., secretary.

N. P. Hayes of Greensboro, N. C., has been elected president of the North Carolina Section of the American Society of Civil Engineers. Hayes, who is vice-president of the Carolina Steel and Iron Co. at Greensboro, succeeds Mason Garber of Winston-Salem, who served as president of the section during the last year. Other officers elected are: E. D. Burchard of Raleigh, junior vice-president; R. E. Stiemke of Raleigh, senior vice-president; and George H. Maurice of Eagle Springs, secretary-treasurer.

At an organizational meeting of a Milwaukee county chapter of the Wis-



Concrete on New Jersey's Pulaski Skyway after 13 years of heavy traffic service.

Replacing 2,500 ft. section of Pulaski Skyway with concrete in 1945.

Pulaski Skyway carrying 60,000 cars per day *now all Concrete*

When the four-lane Pulaski Skyway was built in 1932, concrete pavement was placed on all but a 2,500 ft. section.

For 13 years the Skyway has carried from 40,000 to 60,000 vehicles per day. The concrete is still in excellent condition and has provided uninterrupted service at low cost for maintenance.

In 1945 it was necessary to repave the 2,500 ft. section. This has now been completed with concrete.

Besides concrete's demonstrated ability to carry a heavy volume of traffic at low cost for maintenance, concrete pavement usually costs less to build than any other pavement of equal load-carrying capacity.

Low first cost, low maintenance expense and long life, mean *low annual cost*—the reason why portland cement concrete is the most economical pavement for principal urban and rural highways and city streets.

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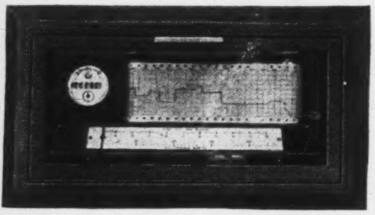

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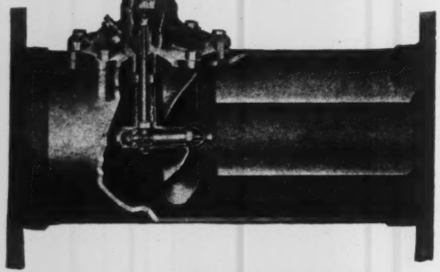

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consin Society of Professional Engineers, Herbert Moore, consulting civil engineer, was elected president, Richard R. Ransom, Cutler-Hammer designing engineer, vice-president, and Robert H. Hopwood, an engineer with Charles S. Whitney, consulting engineer, secretary-treasurer. Directors are: F. T. Agthe, processing engineer with Allis-Chalmers Mfg. Co., Arthur Simon, an engineering and patent consultant, and Ray T. Behrens of the Milwaukee County regional planning commission.

The Illinois Contractors' Association has changed its name to the Associated General Contractors of Illinois. Officers re-elected were: president, F. W. Shappert, Jr., Shappert Engineering Co., Belvidere, Ill.; and secretary-treasurer, T. H. Joyce, Jr., president and treasurer, Joyce Brothers Contracting Co., Springfield. P. F. Loiselle, president, Triangle Construction Co., Kankakee, was elected vice-president. Newly chosen for the board of directors were: Norman Jansen, secretary-treasurer, Jansen and Schaefer, Pekin; and H. H. Hall, H. H. Hall Construction Co., East St. Louis, Ill.

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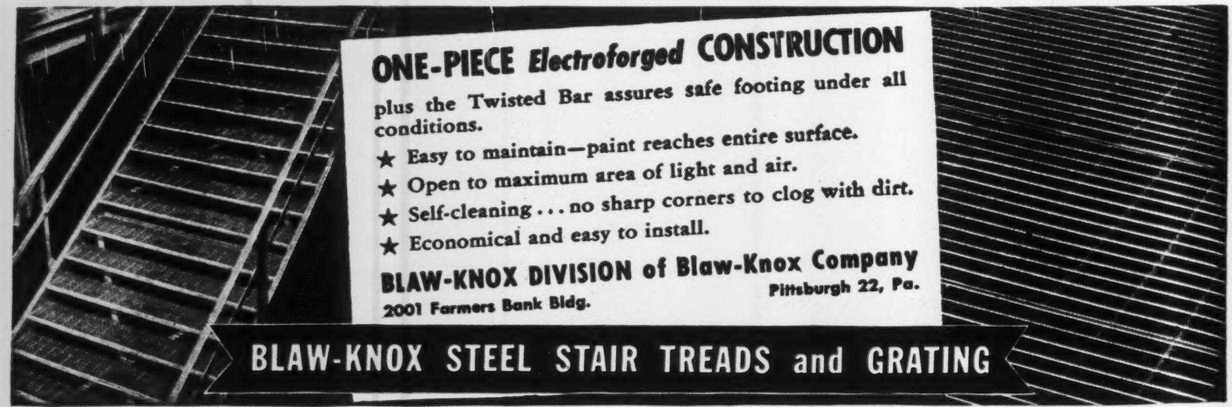
Subway system proposed for Los Angeles, Calif.

Studies of costs and expected traffic for an $80,000,000 city-wide subway system in Los Angeles, Calif., are progressing and may be completed in April, according to a recent statement by K. Charles Bean, chief engineer and general manager of the city's department of public utilities and transportation.

Bean said that the first section, running north and south under Broadway through the heart of the business district, would require at least two years to complete if constructed according to present preliminary plans and that ten years would be required to complete the entire proposed network.



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